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EUROPEAN RESEARCH RESOURCES IN WOOD TECHNOLOGY

Master's thesis for the degree of Master of Science in Technology submitted for inspection, Espoo, 25 November, 2003.

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ABSTRACT OF MASTER'S THESIS

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The purpose of the study was to introduce the current topics and resources of wood technology research in Europe. The main interest was in examining the quality and focal topics of scientific wood technology research in European institutions and finding new opportunities for research networking.

The research methodology consisted of several qualitative elements. First, after initial data collection from publicly available sources, 14 Finnish wood technology researchers were interviewed. Second, the results from the interviews were utilised in defining an appropriate sample for a www-based questionnaire study. The survey was sent to 55 institutions in 12 European countries and the response rate was 53%. Finally the results from the survey were thoroughly analysed in focus group discussions.

The results imply that the most important research areas in wood technology in Europe are structural systems and joints, approval, certification and testing and durability of wood and wood products. On the other hand, it appears that there are certain fashionable research issues where many researches are active. However, these are not the same research areas that wood products industry and funding bodies would regard beneficial. Apart from the fashionable research topics, activities in wood technology research are very scattered in Europe and there is no clear emphasis in it at the moment. Nevertheless, there is a strong motivation among the wood technology research establishments to strengthen collaboration and develop better-functioning research networks in Europe. Informal contacts and joint research projects between organisations were regarded the most valuable practices in cooperation.

As a consequence from the diverse activities and interests in wood technology research, the starting point for future development should be to realise that that the current situation does not meet the strategic objectives of the European wood products industry. This is why a strong common European vision in wood products industry and wood technology research is needed. Even more important is to persuade the different actors in wood products industry and wood technology research to agree on common goals.

Keywords
Wood technology research, research resources, strategic objectives, wood products industry

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Työn tarkoituksena oli esitellä puutekniikkaan liittyvän tutkimuksen painopistealueita ja resursseja Euroopassa. Työssä keskityttiin puutekniikan tutkimuksen laadun ja ajankohtaisten aiheiden selvittämiseen eurooppalaisissa puututkimuslaitoksissa ja uusien verkostoitumismahdollisuuksien löytämiseen.

Tutkimuksessa yhdistettiin useita laadullisen markkinatutkimuksen menetelmiä. Alkuvaiheessa julkisista lähteistä kerätyn tiedon perusteella laadittiin kysymysrunko, jota käytettiin pohjana 14 suomalaisen puututkijan haastatteluissa. Haastattelujen perusteella valittiin otos www-kyselyyn, joka lähetettiin 55 puututkimuslaitokselle 12 Euroopan maassa. Kyselyn vastausprosentti oli 53 %. Lopuksi kyselyn tuloksia analysoitiin johtoryhmän kanssa käydyissä keskusteluissa. Johtoryhmään kuului 9 suomalaisen puutuoteteollisuuden ja 2 Teknillisen korkeakoulun edustajaa.

Tulosten perusteella puutekniikkaan liittyvän tutkimuksen tärkeimpiä alueita Euroopassa ovat puurakenteet ja -järjestelmät, tuotehyväksyntä ja siihen liittyvät testaus- ja sertifiointipalvelut sekä puumateriaalin ja -tuotteiden pitkäaikaiskestävyys. Toisaalta tietyistä alueista on muodostunut muotiaiheita, joita tutkitaan paljon. Nämä ovat kuitenkin alueita, joita puutuoteteollisuus ja tutkimuksen rahoittajat eivät pidä hyödyllisinä puutuoteteollisuuden pitkän tähtäimen strategisten tavoitteiden saavuttamisessa. Muuten puutekniikkaan liittyvä tutkimus on hyvin hajanaista eikä siinä ole nähtävissä selviä painopistealueita Euroopan tasolla. Puututkimuslaitokset ovat kuitenkin motivoituneita kehittämään eurooppalaista yhteistyötä ja etsimään nykyistä paremmin toimivia yhteistyön muotoja. Tärkeimpinä tämänhetkisen yhteistyön muotoina pidettiin epävirallisia kontakteja ja organisaatioiden välisiä yhteistyöprojekteja.

Yhteistyön ja toimintatapojen kehittäminen tulevaisuudessa vaatii vahvaa yhteiseurooppalaista näkemystä siitä, miten puutuoteteollisuuden strategiset tavoitteet aiotaan saavuttaa. Tämä edellyttää kuitenkin ensin sitä, että eri toimijoiden sekä puutuoteteollisuudessa että puututkimuksessa tulee sitoutua yhteisiin strategisiin tavoitteisiin.

Avainsanat	Kieli
Puututkimus, tutkimusresurssit, strategiset tavoitteet, puutuoteteollisuus	Englanti

PREFACE

Internationalisation is a topical theme in wood products industry and wood technology research. Developing well-functioning research networks in Europe is one part of enhancing the competitiveness of European wood products industry. Wood Focus Ltd. ordered this study to discover the current resources and high priority research topics of wood technology research in Europe. The aim of the study was to lay the foundation for the networking process.

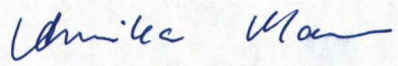
Tero Paajanen, professor of wood technology, has supervised the work and Aarni Metsä, M.Sc. (Tech.) and research director at Wood Focus, has acted as the instructor. Researcher Jussi Virtanen has also actively participated in instructing the work. I would like to warmly thank them all for active support and numerous ideas during the work.

In addition I would like to thank all the members of the research committee of Wood Focus Ltd., who also acted as the focus group members during the study. The focus group meetings gave me valuable insight about the subject.

Researcher Katja Vahtikari and assistant Tero Lahti, with whom I shared a workroom, I would like to thank for numerous inspiring conversations during the project. It has been enjoyable to work with people with such innovative spirit and enthusiasm.

Last but certainly not least I would like to thank Niclas for encouraging and supporting me in everything I do. Your endless faith in me has put me through many difficult times.

Espoo, November 2003



Annika Mauno

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DEFINITIONS

Some of the concepts used in the study are equivocal. To avoid misinterpretations, the central concepts and their definitions as applied in this study are presented in the following.

Core competence

A core competence is a unique capability that affords some type of competitive advantage. It corresponds to a business process, and involves underlying skills, functions, systems and knowledge.

Critical mass

A size, number, or amount large enough to produce a particular result.

EWP

Engineered Wood Products, which include glued building components such as Laminated Veneer Lumber (LVL), Parallel Strand Lumber (PSL), Laminated Strand Lumber (LSL), I-beams and gluelam.

FFIF

The Finnish Forest Industries Federation, a trade organisation for Finnish forest companies who manufacture paper and wood products.

Further processed wood products

Wood products that are manufactured from sawn goods or plywood by gluing, surface finishing or machining.

Publicly funded research institution

A research institution that is financed by the state to a considerable degree.

SME

Small and Medium-sized Enterprises. Companies with less than 100 employees are small enterprises or small businesses. Companies with 100 to 999 employees are called medium-sized enterprises or medium-sized businesses.

Technology transfer

The process by which knowledge concerning the making or doing of useful things contained within one setting is brought into use within another organisation context.

Wood products industry

Sawmilling industry, wood based panel industry and further processed wood products based on them.

1 INTRODUCTION

The purpose of this study is to introduce the research areas and resources of the most important European research institutes concentrating on wood technology. The study was prepared as a Master's Thesis work in the Laboratory of Wood Technology, Helsinki University of Technology (HUT).

The literature review examines how wood industry and scientific instances interact and how research cooperation could be used as a strategic instrument on industry and company level. It specifies the connection between innovation process and research strategies of wood products industry. The experimental part presents the methods and results of studying the resources and interest areas of European wood technology research institutes. Finally, the concluding part indicates the most distinct features and considers the future orientation of wood technology research.

In the first place the study is intended for the client, Wood Focus Ltd., to be used as reference material. In addition researchers and students of wood technology can benefit from an overview of the state of wood technology research in Europe. Because research activities are closely related to industry's business operations, brief descriptions of wood products industry in Finland and Europe are provided. Still, general knowledge about wood products industry in Europe supports understanding the content.

Wood Focus Ltd. is a promotion and research organisation of Finnish wood industry. It aims at increasing the use of wood in building and furnishing and enhancing the image of wood as raw material. To achieve these objectives Wood Focus Ltd. facilitates research and development (R&D) in wood products industry. The research services of Wood Focus Ltd. are based entirely on purchasing research projects from exterior research organisations.

The organisation is divided in to two strategic focus areas, construction and high-quality residential living. The business operations of Wood Focus Ltd. are directed by three committees, namely construction, high-quality living and research, to which the stakeholder companies attend. The decision-making bodies of the company are the shareholders' meeting, which is held annually, and the board of directors, which convenes

four or five times a year. The organisational structure of Wood Focus Ltd. is illustrated in *Figure 1.* (Wood Focus 2003)

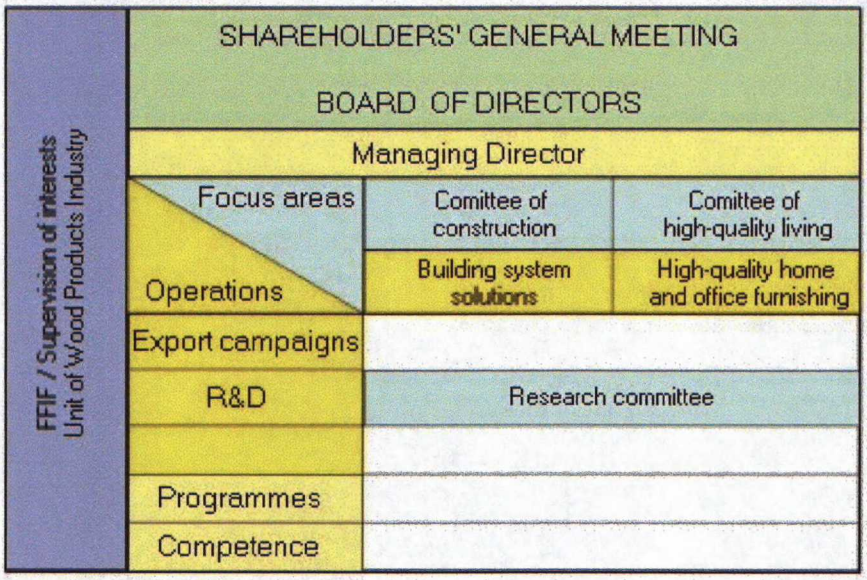

Figure 1. The organisational structure of Wood Focus Ltd. (Wood Focus 2003)

The annual budget of Wood Focus Ltd. is 6,5 million euros, half of which is used for promoting export of wood products. The rest of the budget is divided between purchasing research activities and domestic sales promotion of wood products. The financing shareholders of the company are Finnish forest industry enterprises and trade associations. In addition the company has association partners, who do not give direct financial support. Furthermore the state of Finland possesses shares of the company. More detailed information about the shareholders and association partners of Wood Focus Ltd. is presented in *Appendix 1.* (Wood Focus 2003)

Wood Focus Ltd. operates in close cooperation with the Wood Product Industry unit of the Finnish Forest Industries Federation. The cooperation is based on a shared vision of wood products industry and mission and strategy derived from the vision.

2 DESCRIPTION OF RESEARCH

The study was conducted as a descriptive industrial market research, attempting to gather a depiction of current wood technology research activities in Europe. As a consequence of internationalization, the companies acting in wood products industry need to search mutual modes of operating and uniting R&D resources. The first step in this process was to determine the currently available research resources and networks of relations. The study combined different qualitative methods to gain information about currently active research organisations, their resources and interaction in networks.

2.1 RESEARCH PROBLEM

Essentially the research problems derived from the situation that at the moment Wood Focus Ltd. is planning to expand its operations and thus increase the amount of purchased research activities. At the short-term it intends to strengthen cooperation with European wood research institutes. In the long run Wood Focus Ltd. aims at facilitating research networking and communication within the European research community.

The basic problem was that the client did not have a clear picture of what specific subjects are studied in the leading European research institutes in 2003. The main question essentially directed to identifying the leading wood technology research institutes in Europe and evaluating them. Once the concept of leading institute was defined, the aim was to inspect what their areas of expertise and available resources are. Another related aim was to discover how willing the research institutes would be to provide services for an outside organisation and what forms of cooperation they are interested in.

2.2 OBJECTIVES

The main objective of the study was to provide a description about the current interest areas and resources of wood technology research in Europe. An additional aim was to determine the leading research institutes, which led to evaluating the quality of research conducted in the institutes. The collected information was stored into a database that the client could use in the future as a supporting tool in decision-making. Related to the

main objective, one aim was to create ground for an interactive process so that different parties would discuss common goals in R&D projects and policies.

Considering longer-term goals, the study is part of advancing research networking in wood technology in European Union. The research resources in wood technology are restricted; in many cases one institute distributes its scarce resources to many small-scale operations, which results in inefficient operations. Research activities could be arranged more efficiently if there was a distinct division of work between the organisations. This would enable the research institutes to concentrate on their core competences and cut the number of research topics.

2.3 Restrictions

The study was limited to include certain types of research facilities and European countries. The study concentrated on academic and public research and thus privately owned, enterprise model institutes that aim at making profit were not regarded as the focal point of this study. The viewpoint of the study was how Finnish wood products industry could utilise the research resources available in Europe. Later the results can be used by any actor in European wood products industry or research as a source of information.

Geographically the study included European countries excluding Russia. Although Russia is an important area when considering wood technology research, it was assumed that studying this area would require specific language skills and an inside insight. Thus it was thought to be a suitable subject of an individual study and the client will request a separate study about the topic.

Training and education are closely connected to research activities. It would be an important task to identify the capacity and level of wood technology education in Europe and possibilities of cooperation in this area. However, a more thorough analysis of these themes was out of the scope of this research.

3 WOOD PRODUCTS INDUSTRY IN EUROPE

The business environment of wood products industry forms the context of R&D activities and affects innovation and research management. Wood products industry covers the sawmilling industry, the wood based panel industry and various primary and secondary processed products based on them. Primary processed products include planed goods, finger-jointed timber, veneered plywood and other equivalent products. Secondary processed products are finished products such as windows and doors, furniture, ready-to use timber components and complete wooden houses. (Key to the Finnish Forest Industries 2000) The significance and structure of wood products industry in Europe and Finland are introduced briefly in the following.

3.1 PRODUCTION VALUES

The value of production of the European wood and furniture industries reached 163 billion euros in 2000. *Figure 2* shows the breakdown of European wood products industry. The most important sector was furniture, accounting for 59% of the total production. Second was the sector of wooden construction elements, 13% of the overall production value. Sawing, planing and impregnation were third with the share of 11%. The sector of wood-based panels sector was less significant, 8% of the total production. (CEI-Bois 2003)

In Finland the emphasis of wood products industry is different from the general European situation. *Figure 3* shows the breakdown of Finnish wood products industry. The total value of production in the Finnish wood products industry amounted to 6,3 billion euros in 2001. The most important sector was sawmilling and the second was wood based panel industries. Together they formed 57% of the total turnover. The furniture industry in Finland accounted for 19% of the total production. (The Finnish Forest Industries Facts and Figures 2003, p. 14)

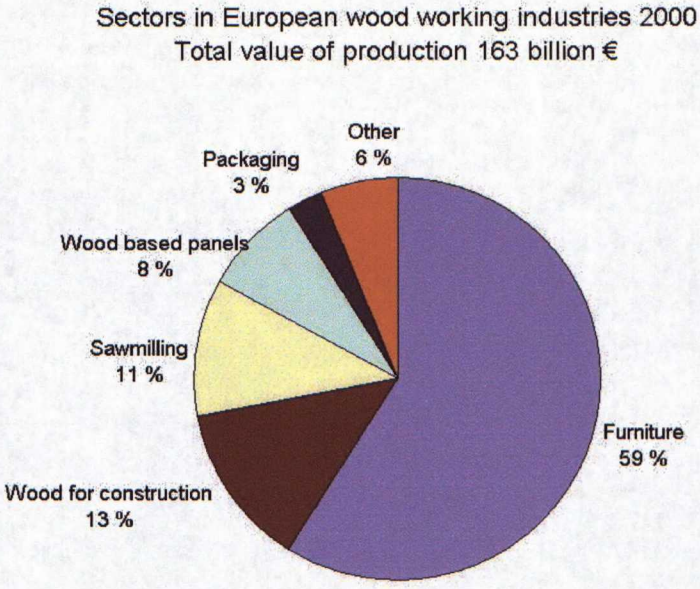

Figure 2. Breakdown of European wood products industry in 2000. (CEI-Bois 2003)

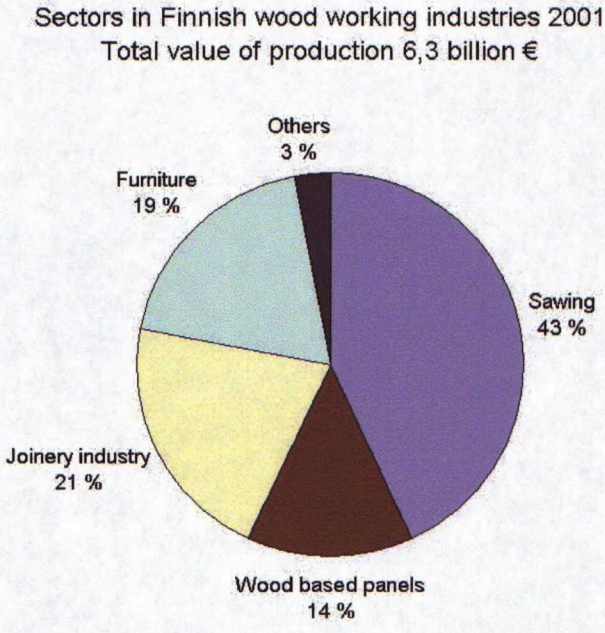

Figure 3. Breakdown of Finnish wood products industry in 2001. (The Finnish Forest Industries Facts and Figures 2003, p. 14)

3.2 INDUSTRY STRUCTURE

Despite of the relatively large size of the European wood products industry, its structure is scattered: there are many small and medium-sized companies. The Finnish wood products industry differs significantly from this pattern, as there are three large corporate groups that are very powerful. *Figure 4* illustrates the position of the Finnish wood product companies in European wood products industry. (Peura 2001; Paajanen 2003)

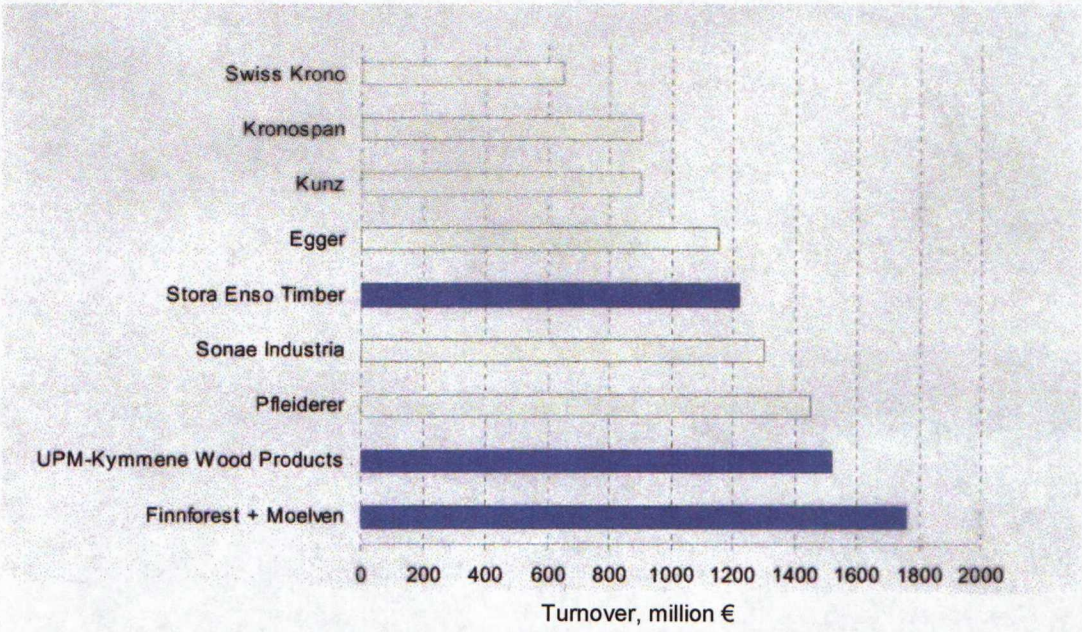

Figure 4. The largest West-European corporations in wood products industry by turnover. The blue bars represent the three largest Finnish companies. (Paajanen 2003)

In Finland the share of the three largest Finnish forest industry groups is almost half of the country's total sawn wood production. The number of sawmills in Finland is currently 130. The medium-sized, non-integrated sawmilling industry has, nonetheless, expanded its share of total production in the 1990s. (Key to the Finnish Forest Industries 2000, p. 24)

In the Finnish plywood industry, the three major corporations account for about 90% of the total production. The number of particleboard producers in Finland is currently

three, and there is just one manufacturer of fibreboard and laminated veneer lumber (LVL). The joinery industry, excluding production of wooden houses, comprises almost 800 business units throughout Finland. (Key to the Finnish Forest Industries 2000, p. 24)

3.3 DEVELOPMENT TRENDS

Long-term growth is going to lead to a situation where building components manufactured from timber and combinations of wood products increase their share. However, European wood product industry will face several challenges that relate to rapid technological development and availability of skilled human resources. More efficient performance in terms of environmental issues and productivity are needed in order for the industry to stay competitive. The increasing degree of internationalization and growing competition from low cost countries create pressure to develop technologies that would yield in lower input costs and better product quality. (Key to the Finnish Forest Industries 2000, p. 25; Seppänen 2000)

In addition, to meet the customers' requirements wood products industry should direct its R&D activities in a more customer-oriented manner. Maintaining competitiveness requires increased efforts in R&D, innovation process and dissemination of research results. (Seppänen 2000) Thus the central challenges of European wood products industry can be summarised as follows:

1. Internationalization
2. EU enlargement
3. Environmental issues and energy
4. Technology and know-how. (Paajanen 2003)

In Finland production in the sawmilling and wood based panel industries is based on wood raw material from domestic sources. The availability of Finnish wood raw material sets limits on how much the basic industry can grow; the use of domestic raw material can not be increased significantly from the present. The only way to increase production and turnover in wood products industry will be to increase the degree of processing and add more value to the end product. (Key to the Finnish Forest Industries

2000, p. 25)

Another trend is that the production of Finnish-owned sawmilling industry shifts from Finland to other countries. It has been estimated that by 2005 the increase in such production will increase by 30 % from the level of year 2002. This would mean an increase in production volume outside Finland from 8 million m^3 in 2002 to 10,5 million m^3 in 2005. The increase in production outside Finland will mainly concentrate on Eastern Europe. (Paajanen 2003)

4 INNOVATION PROCESS

Cooperation between academic world and industry supports the companies' business operations in many aspects. One of the most important benefits of the collaboration is that it improves companies' capability to introduce advanced innovations; the key advantage of linking to several external relations is that the diversity of contacts promotes the realisation of innovation projects. Since this connection is fundamentally important, this chapter introduces the general concept of innovation and explains different innovation models in more detail.

4.1 DEFINITION OF INNOVATION

Innovation can be defined shortly as the introduction of something new (Merriam-Webster OnLine 2003). Another definition of innovation states that it is implementing new ideas to create value (Innovating Europe 2003). To give a more thorough interpretation of the concept, innovation can be characterized as follows:

> "Innovation occurs when a new or changed product is introduced to the market, or when a new or changed process is used in commercial production. The innovation process is the combination of activities - such as design, research, market investigation, process development, organisational restructuring, employee development and so on - which are necessary to develop and support an innovative product or production process." (London Innovation 2003)

To summarise the above, it can be stated that there are four terms that identify innovation:

1. Someone has to take action to create innovation
2. Innovation is change and gives birth to change
3. Innovation happens in a context
4. Innovation gives new value to an existing situation. (Innovating Europe 2003)

Innovation occurs through the interaction between the science base, technological development and the needs of the market. The overall framework of innovation indicating this interaction is illustrated in *Figure 5.* The traditional linear model of innovation suggests that innovation is a sequential process from research to production to market, where research acts as the driving force. Currently innovation is regarded more as an evolutionary, non-linear and interactive process. The process includes feedback loops from market to R&D and vice versa. (Trott 2002, p. 17; Kaufman & Tödtling 2001, p. 792)

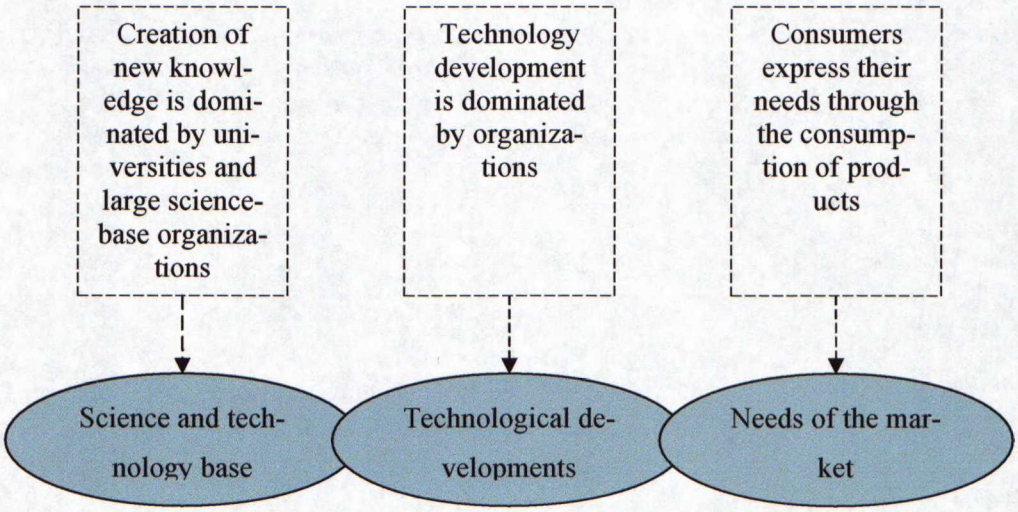

Figure 5. The conceptual framework of innovation. (Trott 2002, p. 17)

4.2 LINEAR INNOVATION MODEL

The traditional linear innovation model is a sequence of separable stages. There are two basic variations of the linear model: the technology-push and market-pull models. The first model regards markets as a passive recipient for the outcomes of R&D. The market-pull model, on the other hand, realises that marketplace has an important role in innovation. It emphasises marketing as an initiator of new ideas resulting from close customer co-operation. These are conveyed to R&D for design and to manufacturing for production. *Figure 6* clarifies the differences between the two linear innovation models. (Trott 2002, p. 17)

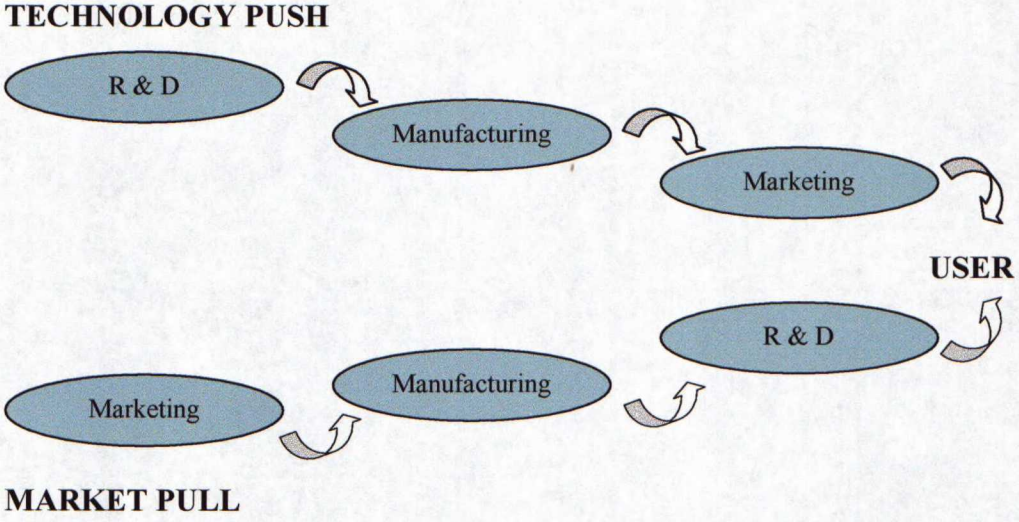

Figure 6. The two basic variations of the linear innovation model. (Trott 2002, p. 18)

4.3 INTERACTIVE INNOVATION MODEL

The interactive innovation model links together the two linear models. It emphasises that innovations occur as the result of three basic components: interaction or the marketplace, the science base and the organisations' capabilities. The generation of ideas depends on these basic components. The interactive model, which is illustrated in *Figure 7*, presents innovation as a sequential process that can be divided into distinct stages, which are interacting and interdependent. (Trott 2002, p. 18)

Interactivity of the innovation process refers to the internal collaboration between a company's departments and external cooperations with other companies, knowledge providers, finance, training and public administration. Thus a wide range of partners may contribute to a company's capacity to innovate. It should be noted that linkages with the science base and the marketplace occur between all functions. (Kaufman & Tödtling 2001, p. 792; Trott 2002, p. 18)

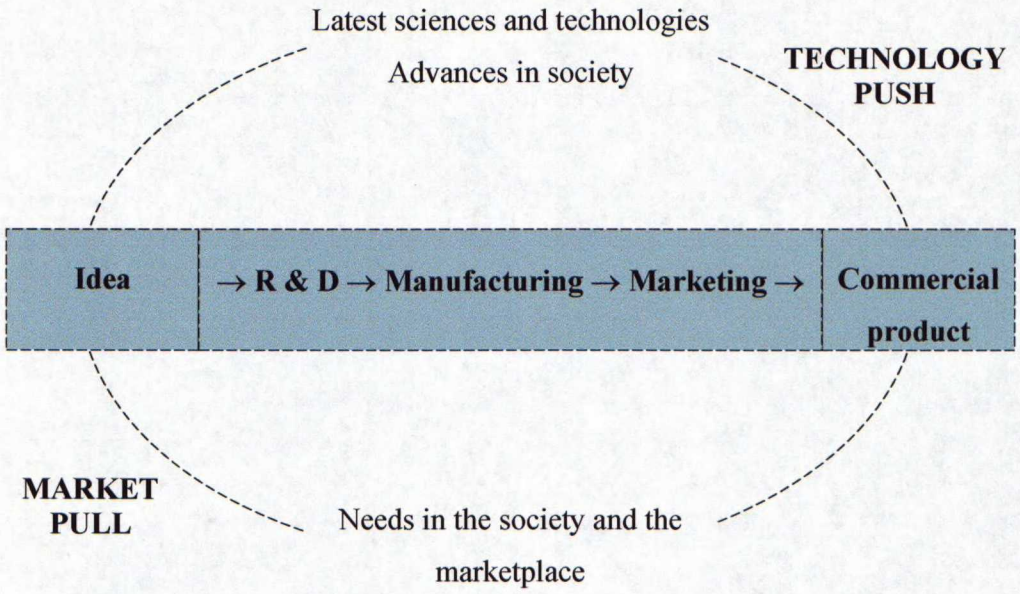

Figure 7. The interactive model of innovation. (Trott 2002, p. 19)

4.4 INNOVATION IN WOOD PRODUCTS INDUSTRY

In wood products industry Paajanen et al. (2000) have introduced the concept of key technology implementation. Similarly to the interactive innovation model, this concept emphasises reconsidering the conventional linear innovation chain as a circle where basic research, applied studies, development and marketing take place simultaneously. In the traditional research manners new theoretical knowledge leads to applied research and further to practical product and production development. Oriented research, on the opposite, leads to key technology implementation and implies to simultaneous progress in developing theories, applying research results and developing products. (Saarenmaa & Paavilainen 2002; Paajanen et al. 2000, p. 16)

The main benefit from implementing key technologies is that when the implementation is successful, commercial results can be achieved in a short time. This is the main feature differentiating key technology implementation from other research approaches: in key technology implementation the time needed from research to market is considerably shorter. *Figure 8* illustrates the time needed for classical innovation chain and key tech-

nology implementation. In practise key technology implementation is the only method to progress in such areas where no or little basic research is done and where the tradition does not support the development process. (Paajanen et al. 2000, p. 17)

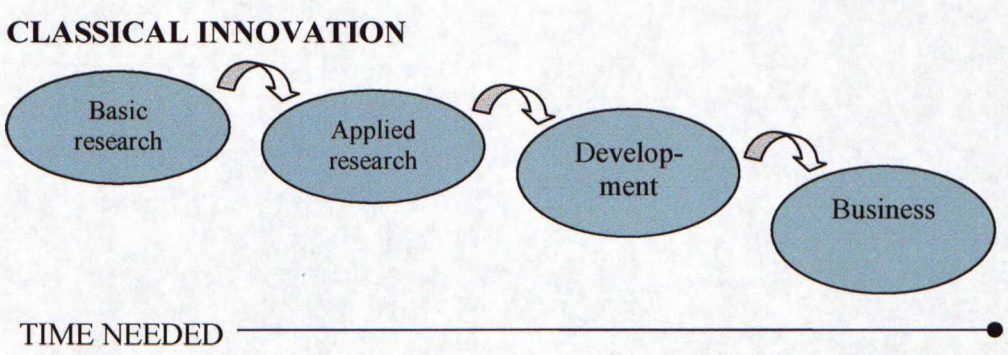

Figure 8. The time needed for classical innovation chain and key technology implementation. (Paajanen et al. 2000, p. 16)

Klus & Hirvensalo (1997) have defined certain essential tasks in key technology areas. The tasks answer to the questions *what* is needed to be achieved and *how* the aims are to be achieved. *Table 1* presents these necessary tasks.

Table 1. The necessary tasks in key technology areas. (Klus & Hirvensalo 1997, p. 35)

WHAT?	HOW?
Technological area is driven by the business. Development is crucial to reach a competitive edge.	The required basic research is specified. Centres of excellence are to be developed.
The goal is to become an international leader in the area.	Critical mass both in knowledge and finance are to be reached.
To solve the problems interaction between basic and applied R&D is promoted.	The core competence is to be specified and the international collaboration is to be developed.

5 R&D AS A STRATEGIC INSTRUMENT

In a branch of industry, the companies should be able to direct R&D activities according to their strategies. To achieve this, the companies either need human resources to conduct the necessary R&D themselves or they must possess the necessary knowledge to be able to direct the R&D activities to outside institutes. In either case, expertise is required to utilise research results in practise in industrial companies. The connection between research activities and business strategy is elaborated more thoroughly in the following. To begin with, the concept of research is considered in more detail.

5.1 DEFINITION OF RESEARCH AND DEVELOPMENT

Briefly the concept of research and development can be defined as developing and applying scientific or engineering knowledge to connect the knowledge of one field to that in others. Research is original investigation that is undertaken in order to gain knowledge and understanding. It includes work that is relevant to the needs of industry, public and voluntary sectors. It is invention and generation of ideas, images, performances and artefacts and the use of existing knowledge in experimental development to produce new or substantially improved materials, devices, products and processes. It excludes routine testing and analysis of materials, components and processes, such as the maintenance of national standards, as distinct from the development of new analytical techniques. (Trott 2002, p. 293; HERO 2003)

An active and well-functioning research culture is a precondition to successful research activities. Culture refers to attitudes, expectations, behaviour and structures for conducting basic and applied research, allocating resources and applying the research results. Research culture comprises of

1. *Intellectual structure*, which includes the process for specifying goals, decision-making process and models of operation in R&D.

2. *Infrastructure*, which consists of financial resources, research resources, research facilities, knowledge development and collaboration between universities and research institutes. (Klus & Hirvensalo 1997,

p. 26)

In general, research and development activities can be categorised in three fields depending on their objectives: basic research, applied research and development. These are not clearly distinct phases because it is not possible to determine exactly, where research ends and development begins. However, they can be roughly distinguished as follows:

1. *Basic research* refers to fundamental science that involves work of a general nature intended to apply to a broad range of uses or to a new knowledge about an area.

2. *Applied research* indicates application of science that involves the use of existing scientific principles for the solution of a particular problem

3. *Product development* denotes application of science that involves the use of existing scientific principles to overcome a technical problem associated with a particular product. (Trott 2002, p. 302)

To further illustrate the overlapping character of research activities, they can be presented as a continuum with scientific knowledge at one end and physical products at the other end. The research result shifts from intangible to tangible accordingly. *Figure 9* illustrates the continuum of R&D. (Trott 2002, p. 292)

The concept of research can have different meanings for different interest groups. From an industrial point of view research is a generic concept. It includes both new science and the use of old science to produce a new product. In academic surroundings research traditionally refers to the systematic approach to discover new knowledge. The main difference between the two approaches is that company and contract R&D focuses more on such R&D that can be rapidly commercialised. Pure academic research, on the other hand, is independent from economic considerations. (Kaufman & Tödtling 2001, p. 800)

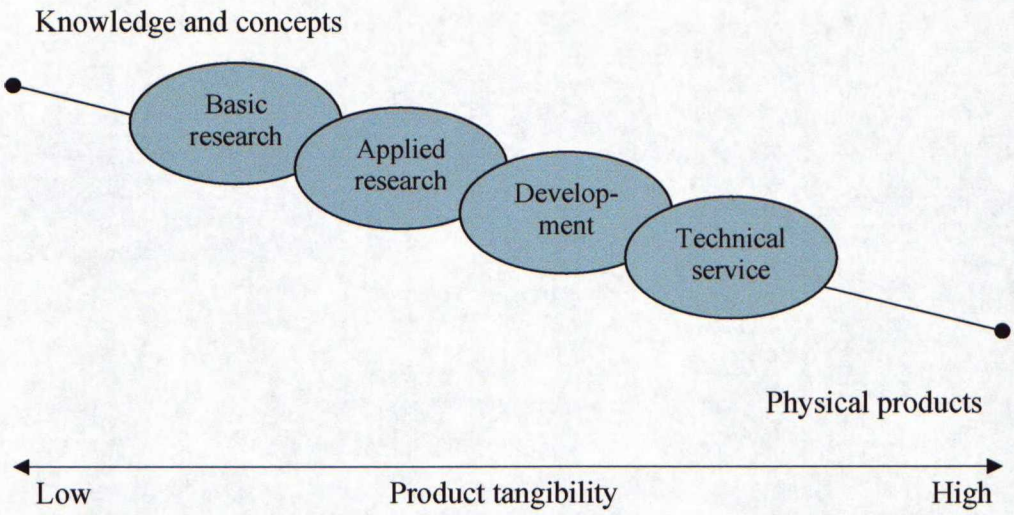

Figure 9. The continuum of research and development. (Trott 2002, p. 292)

As a result from the different emphasis, the orientation of researchers varies depending on whether they are working at universities, in contract research organisations or in companies. Because the organisational contexts are different, the focus of research is also different. The interests of different systems are conflict: in industrial research access to the research results is restricted through patents and secrecy. In addition researchers in profit-oriented establishments must consider the business systems' ways of operation. In academic research, on the contrary, the main interest is in the publication of the results. As a consequence of the contradictory concerns, industry research concentrates on applied, short-term research whereas academic research is directed to basic research with a considerably longer time span. *Figure 10* illustrates the different emphasis in industrial and academic research. (Kaufman & Tödtling 2001, p. 792)

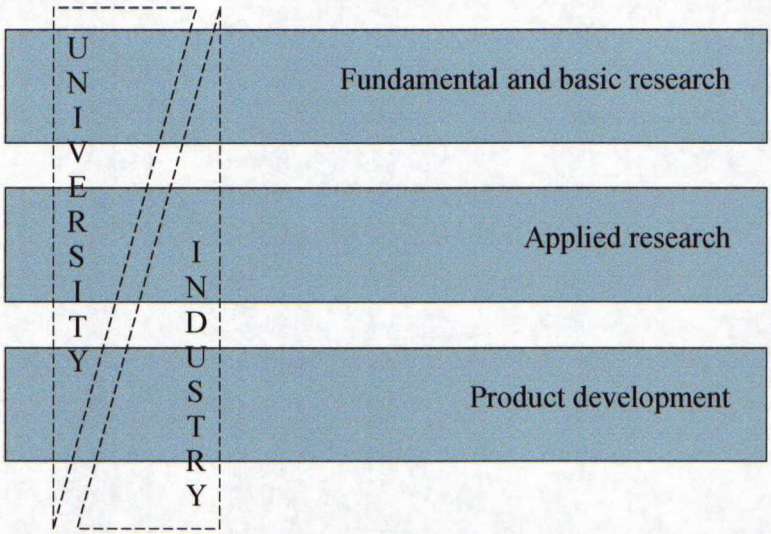

Figure 10. Research emphasis in industry and universities. (Trott 2002, p. 300)

5.2 PUBLICLY FUNDED RESEARCH

As was mentioned in the previous section, universities and other publicly funded research institutions are important sources for private sector innovation activities. They absorb and accumulate knowledge created elsewhere, generate new knowledge through their own research and diffuse the knowledge into the society in several ways. Providing scientific knowledge to companies is the most widely recognised contribution of public research. In other words, they have an important role in *knowledge transfer* in society.

There are three main stakeholder groups, each of which has its own expectations to the public research institutions' operations. These interest groups are government, industry and other transfer partners. Government authorities, being the main financing body, want to maximise the economic and social impact of public research to the society. (Braun et al. 2000, p. 3)

Industry expects to access and overcome new technologies with the help of public research institutions. In most cases industrial companies would not be able to develop or apply the new technologies by themselves, but they need to collaborate with research institutes. Industry also expects public institutions to provide contract research and consulting services. (Braun et al. 2000, p. 3)

Finally there is a group of other partners, which participate in the process of technology transfer. This group includes other research institutions and business support organisations and intermediary services. Other research institutions profit from collaboration, because the nature of technologies is increasingly becoming interdisciplinary. Each research institute focusing on highly specialised areas creates a need for collaboration between the institutes. The other partners anticipate the public research institutions to act as sources of expertise and active participants in projects. (Braun et al. 2000, p. 3)

5.3 TECHNOLOGY TRANSFER

Technology transfer is the process by which knowledge concerning the making or doing of useful things contained within one contained setting is brought into use within another organisation context. To stress the importance of successful technology transfer, Saarenmaa & Paavilainen (2002) suggest that the success in technology transfer should be regarded as the main criterion when evaluating the results of any research project.

Technology transfer can be classified into three fields according to the mechanism that is used to communicate the results of scientific research into industrial application. These fields are:

1. Publications
2. Patents
3. People links. (Cutler 1989, p. 17-18)

The practices of transferring know-how have gradually shifted from formal to informal over time. Traditionally transferring know-how has mainly used established channels of scientific communication such as scientific publications and conference presentations. The traditional forms of knowledge transform rely immensely on the codification of the information such as scientific publications. Other, more informal types of knowledge transform require personal interaction such as

- Education of students
- Carrying out contract research
- Consulting

- Training of personnel
- Conducting joint projects between research institutions and private companies
- Exchanging know-how informally.

Lately staff transfer has become more important with greater collaboration with industry. It has even been stated that personal contacts are the most important method of transferring knowledge. *Figure 11* introduces the instruments and channels of technology transfer in detail. (Braun & al. 2000, p. 7; Fritsch & Schwirten 1999, p. 69)

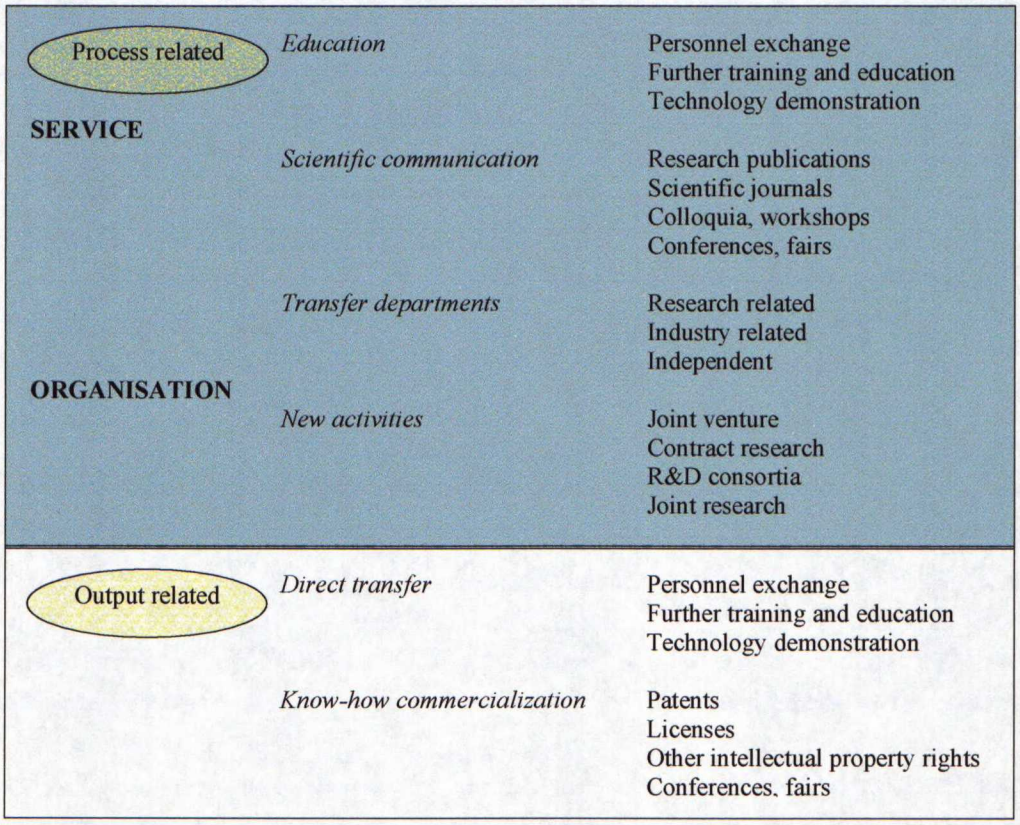

Figure 11. Instruments and channels for technology transfer. (Braun et al. 2000, p. 9)

However, knowledge transfer is more than just the transfer of a technology developed in an institution. Additional adjustment and development work is required to meet the needs of the end user. This requires transferring knowledge more efficiently from research results to practise for the people who actually use that knowledge. In this diffu-

sion of research results, technology is primarily transferred by people, not via organisational charts or formal reports. Personal communication and technical collaboration are the key factors, rather than e.g. availability of scientific journal literature or efforts to promote university patents. (Braun et al. 2000, p. 7; Cutler 1989, p. 23)

In practise the problem is that research projects are often directed only to the research community. Researchers are often reluctant to interpret their results in terms of development and business. Instead, they prefer to raise new research questions rather than solve actual problems. Thus there is a need to disseminate the information to users in a less theoretical way. (Ranta-Maunus & Toratti 2001, p. 16; Saarenmaa & Paavilainen 2002)

Apart from knowledge, science also provides new instruments, techniques and methods that are applicable in companies' research and development activities. Scientific knowledge can often be transferred to a wide range of commercial applications and the nature of new technologies based on scientific knowledge is often non-specific. Thus they offer potential for further product innovations and new markets. (Kaufman & Tödtling 2001, p. 800)

To summarise the knowledge and technology transfer activities and their connection to research and development, *Table 2* gathers the important characteristics of different research approaches from several perspectives.

5.4 LINK FROM R&D TO BUSINESS STRATEGY

Business strategy states an organisation's basic direction for the future. The key elements in formulating business strategy include long-term objectives set by the senior management, features of the operating environment in which the organisation competes and the organisations capabilities and heritage. The last element refers to the skills and resources acquired over the organisation's history. Building a stock of knowledge and skills through experience is not only an internal process; the external linkages that the organisation has formed over time have significance, too. Thus investing in the relationship network can form a competitive advantage for the organisation. (Trott 2002, p. 91, 93)

Table 2. The different perspectives and characteristics that drive value creation in research activities. (Braun et al.2000, p. 6)

	Basic research	Applied research	Development
Perspective		*Characteristic*	
Financial	▪ 80-100 % public funding ▪ No profit objective	▪ 50 % public funding ▪ Break even objective	▪ 100 % external revenues ▪ Profit objective
Process	▪ Research process robustness	▪ Application process effectiveness	▪ Commercialisation process effectiveness
Customer	▪ No customer identified	▪ Technology forecasting ▪ Customer clusters	▪ Marketing research
Social	▪ Production of new knowledge	▪ Production of new technologies	▪ Creation of new activity
Innovation potential	▪ Learning from academic research	▪ Learning from basic research	▪ Learning from applied research
Organisation & culture	▪ Independence of labs and researchers	▪ Interaction with industry	▪ Customer / provider relationship

To be able to direct research and development activities according to their strategies, companies need experts who can use the knowledge embedded in research reports. Academic skills are thus needed to interpret research results in such a way that innovations can emerge in an industry. An ideal situation would be continuous cooperation between companies and research institutes. If academic skills can be combined to product development, both the company and the research institution gain advantages. The process from a general research policy through knowledge and technology transfer to creation of business opportunities can be regarded as a value chain, which is illustrated in *Figure 12*. (Saarenmaa & Paavilainen 2002)

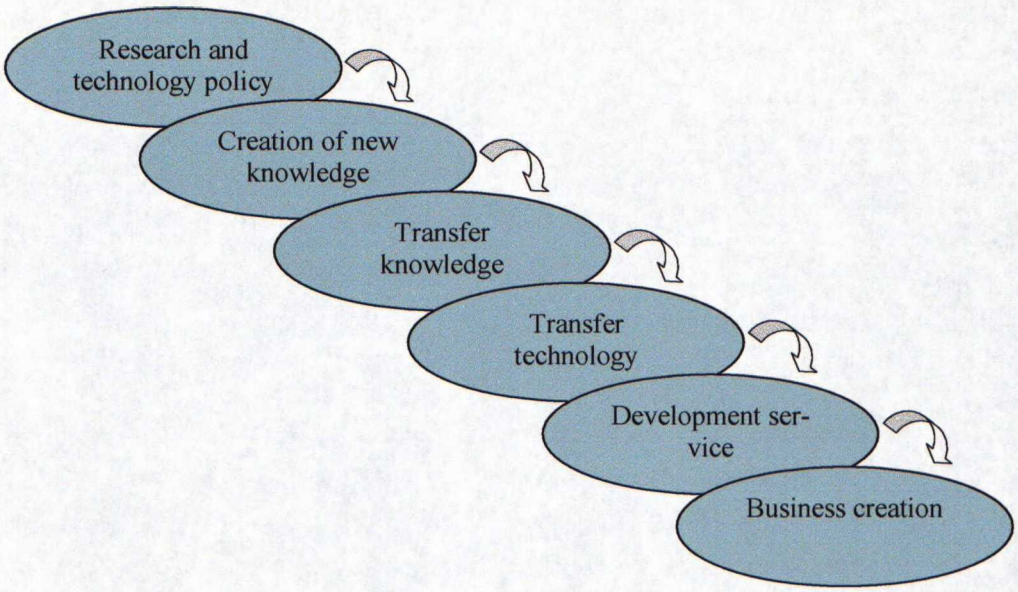

Figure 12. The value chain of technology transfer. (Braun & al. 2000, p.7)

As the technological environment where the companies operate has become increasingly complex, the technical self-sufficiency of companies has decreased. An individual company cannot alone control the technologies its operations require. Because the scientific knowledge is scattered to a large number of people, interaction is a prerequisite for a company to survive in the intensifying competition. (Bougrain & Haudeville 2001, p. 735)

Additional motives for research networking derive from shortening product life cycles and high costs of research and development. For research and development, capital and the technical critical mass are often the insufficient resources. Building and sustaining the necessary expertise and specialised equipment are utterly expensive. Thus it is becoming increasingly difficult for any company to adapt its technical capabilities to fast-paced market dynamics. In such situation cooperation with other organisations becomes an attractive alternative. The partner organisation can be either private, profit-oriented companies or publicly funded establishments. (Trott 2002, p. 116)

6 STRATEGIC RESEARCH AREAS IN WOOD TECHNOLOGY

In Europe wood research is considered to be important for three main reasons. First, Europe is a considerable forest-power and consumer of wood. Second, there is a demand for an optimised and sustained utilization of renewable raw material because the raw material and energy resources are limited. Finally, wood competes intensely with other widely diffused materials such as steel and concrete. As a consequence more and more basic knowledge about wood as a raw material is required. (COST Action E8 1996)

There is one notable weakness in wood technology research on European level: the poor ability to transform results of research work into industrial and commercial success. As a consequence, the authorities of EU encourage R&D of forest based and related industries in several ways. To enhance the competitiveness of forest based and related industries, the authorities encourage using more research funds on the development and use of timber products. In addition they stress the importance of timber products in the storage of carbon and encourage the public to use timber products in construction. (Seppänen 2000) On the other hand, it is difficult to find tangible proof of the encouraging activities of EU: wood technology research achieves only little EU financing compared to other fields of research.

Accumulating European knowledge and research in wood technology in the future is also a national advantage for the Finnish wood products industry. Through this it would be possible to effect positively on the competitiveness of wood against other materials internationally. The focus should be on promoting use of wood against other materials rather than promoting use of Finnish wood against wood from other countries. (Wood Wisdom Forum II 2000) To achieve a competitive advantage for use of wood, the wood products industry needs to direct research and development activities according to their strategies. This chapter presents the strategic objectives of the Finnish wood products industry and the related strategically important research areas in wood technology.

6.1 PRIORITIES IN WOOD TECHNOLOGY RESEARCH

Currently two crucial development trends effect the priorisation of research and development activities in wood technology:

1. Shift from solid wood products to engineered wood products
2. Utilisation of information technology in wood manufacturing and processing.

In addition ecological arguments for using wood should be specified by standardising the calculation methods for life-cycle assessment. (Peura et al. 2000)

Based on these development trends and the strategic objectives of the Finnish wood products industry, the following five research areas have been proposed as the key technology areas in wood technology research:

1. Wood product systems
2. Ecology as a competitive advantage of wood products
3. Intelligence in wood products and their production
4. New wood products and their value chains
5. Chemistry of wood products, modified wood, engineered wood products and making them marketable. (Peura et al. 2000)

Peura (2003) has emphasised that wood products industry should realise the importance of other research areas than merely research related to the use of end product. It is important to recognize that there is a continuum from wood material science through key technologies and products to business operations. *Figure 13* illustrates how each phase of the continuum is based on the previous ones. It also presents examples of specific research topics related to each phase. The concept of own key technologies in the figure refers to research areas in wood technology such as drying, modification, gluing, machining and preservation. Applied key technologies include value chain management, automation, information technology and modelling, for example.

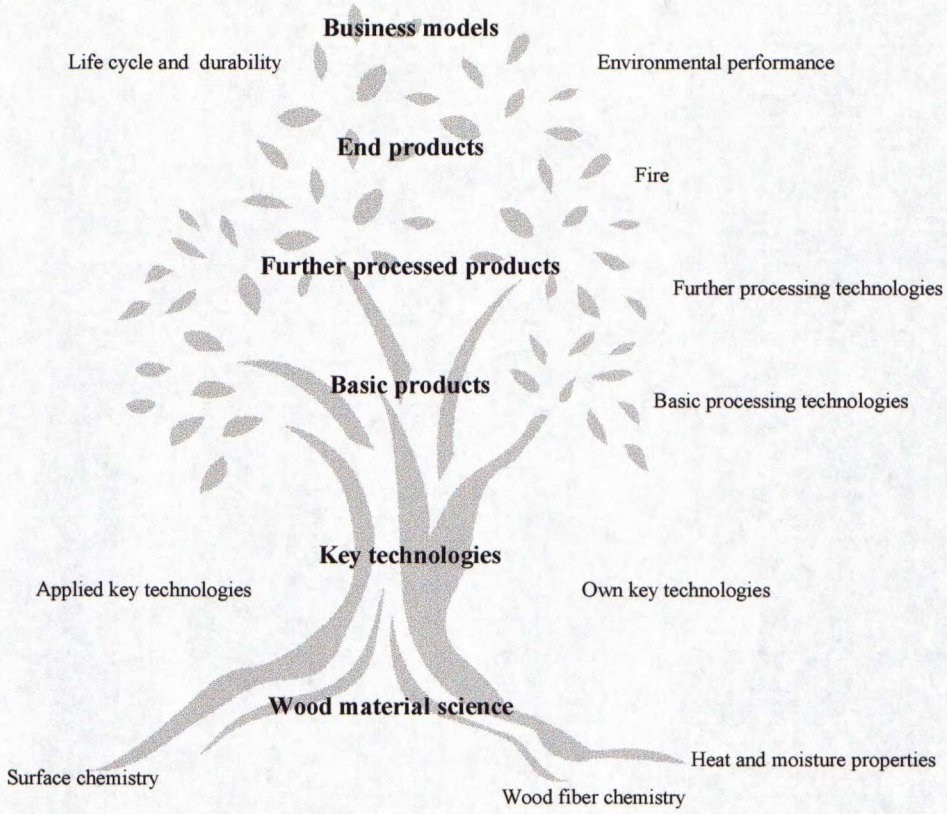

Figure 13. The link from wood material science through key technologies to business operations (Figure adapted from Peura 2003)

6.2 STRATEGIC OBJECTIVES OF FINNISH WOOD PRODUCT INDUSTRY

The Finnish wood products industry has agreed on a common objective for the future, called Vision 2010. Paajanen et al. (2000, p. 7) have expressed the Vision 2010 as follows:

> "By the year 2010 wood will be Europe's leading material for building system solutions and for high quality home and office furnishings. For Finnish wood products industry the aim is to be the leading provider of wood products and services in European wood product markets. The Finnish know-how will have a positive image domestically as well as globally and the total turnover of the industry will have doubled."

According to the Vision 2010, construction industry is and will remain the main customer for wood products. Therefore it is natural that one strategic area of wood products industry and research is building with wood. Wood products are not only consumed in construction but also considered in a social context. Thus the other strategic area of the wood products industry has been defined to be living with wood. All resources in the wood products industry will be concentrated on these two strategic areas. *Figure 14* demonstrates how R&D activities have an important function in the strategic areas. (Wood Focus Ltd. 2003; Key to Finnish Forest Industries 2000, p. 25)

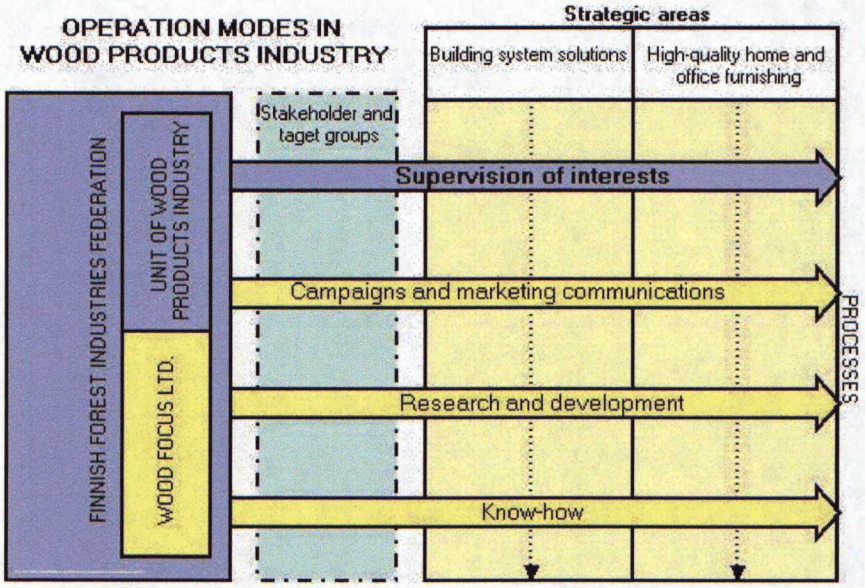

Figure 14. Link from the strategic areas to wood products industry and promotion organisations. (Figure adapted from Wood Focus Ltd. 2003)

The basis of the Vision 2010 has been a want to develop an international mode of operating that centralises around knowledge and skills. The *objectives* of Vision 2010 are to:

- Examine what are the relevant mega trends to year 2010 that could affect the use of wood.
- Enhance the strategic know-how of Finnish wood products industry.
- Create a shared vision for wood products industry.
- Create a strategy for wood products industry to achieve the vision.
- Oblige different interest groups to commit to the shared vision.

- Create a practical model of operating to accomplish the vision.
- Guide investors' decisions in developing the Finnish wood products industry. (Wood Wisdom Forum II 2000)

The principles of Vision 2010 have a significant impact on wood technology research in Finland and Europe. Wood technology research should result in an offensive strategy to generate favourable conditions for using wood products. On European level this requires establishing standards that contribute to using wood. To achieve the strategic objectives of wood industry, a broad joint effort is needed. Accomplishments from different fields from research to industry and trade are needed to achieve the common goal. The stakeholder groups needed to participate in this process are specified in *Figure 15.* (Wood Wisdom Forum II 2000; Ranta-Maunus & Toratti 2001, p. 9)

In addition to developing more intensive networks, achieving the Vision 2010 requires thorough understanding and employing the key technology implementation. Paajanen et al. (2000) have introduced the following six steps in implementing key technologies:

1. Define targets for development from practical needs.
2. Define related objectives for basic and applied research.
3. Establish research groups in the key areas.
4. Improve the cooperation between research groups.
5. Connect research results to industrial product development.
6. Utilise research and development results in company's business operations.

In key technology implementation it is possible to construct internationally high-level research groups. These groups are characterised by internationally notable level of knowledge. In the groups the essential critical mass is achieved they advance collaboration and utilising results in a versatile manner in companies' business operations. (Paajanen et al. 2000, p. 18)

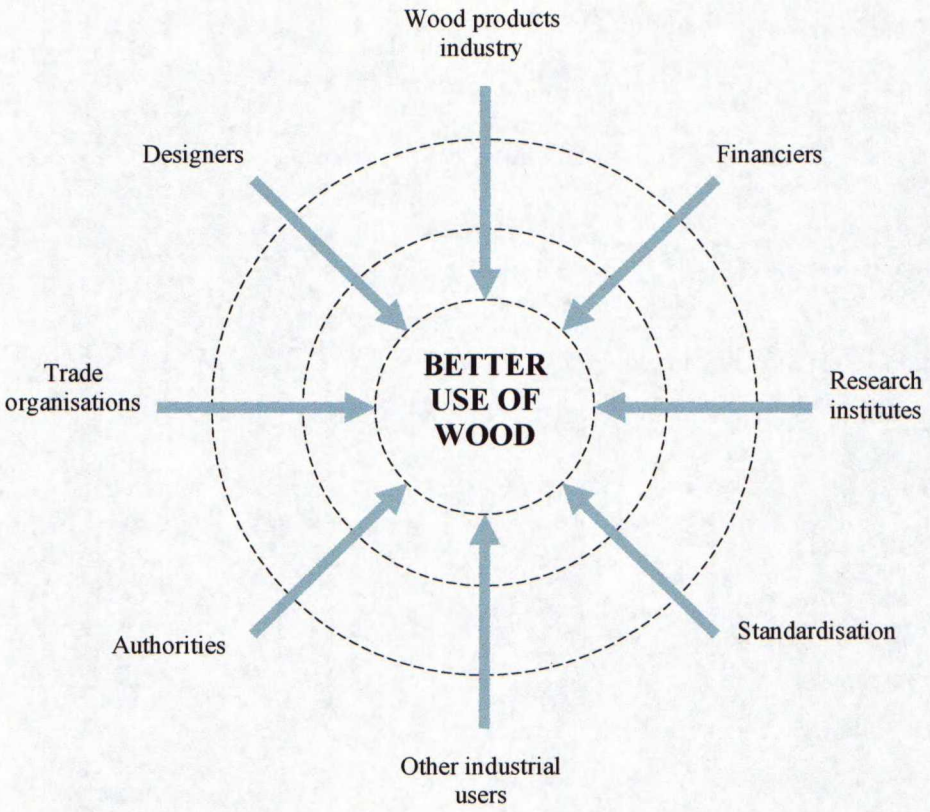

Figure 15. More competitive use of wood requires different stakeholder groups to network and operate together to achieve a common goal. (Figure adapted from Ranta-Maunus & Toratti 2001, p. 10)

6.3 Competitiveness of Finnish wood products industry

In Finnish wood products industry the companies have not traditionally been heavily involved in research and development activities, because production has concentrated on basic wood products. Since the products of every manufacturer have been similar, development activities have primarily aimed at cost reduction by rationalising operations and increasing the degree of automation. This has led to machine manufacturers being the most active party in wood technology research and development. It has not been until during the recent years that a greater interest in research and development has emerged within the wood products industry. (Klus & Hirvensalo 1997, p. 7; Paajanen et al. 2000, p. 16)

As discussed in the previous section, the Finnish wood products industry has agreed on two strategic areas: building with wood and living with wood. This strategic objective requires promoting industrial basic and applied research in specified key areas of the material science of wood and developing system products in wood construction. Conventionally in wood technology basic research has not been valued, because the industry has lacked evidence of how basic research benefits their business. (Saarenmaa & Paavilainen 2002; Paajanen et al. 2000, p. 16)

Developing system products in wood construction obviously creates a need for critical mass and collaboration, because an individual player cannot change the wood construction system. A critical mass can be achieved by deepening and extending research cooperation, which ensures efficient and flexible use of scarce resources. Increasing the visibility of research increases also the mobility of researchers and supports a creative research culture. As a result, a division of work and specialization between countries and research facilities can be developed. (Saarenmaa & Paavilainen 2002)

Wood products industry would benefit from strengthening and harmonising R&D activities in wood technology across Europe in several ways. Research collaboration strengthens the competence base for long-term industrial competitiveness. Establishing a sound knowledge base is important in wood products industry because it enables the development of innovative wood-based products and adding value in the wood products industry. (Ranta-Maunus & Toratti 2001, p. 9; Saarenmaa & Paavilainen 2002)

To network more effectively, wood products industry needs to establish new methods of collaboration between companies and wood technology research internationally. This requires breaking traditional barriers between disciplines and business sectors, building closer links between research units with different backgrounds and supporting networking within the forest cluster. (Saarenmaa & Paavilainen 2002)

To summarise the above discussion about research orientation and the significance of research collaboration, the long-term industrial competitiveness requires actions in two fields: strengthening of certain research inputs and advancing research collaboration both domestically and internationally. *Table 3* defines the relations between the long-term goal of wood products industry, research resources and research collaboration. (Salo et al. 2002, p. 10)

Table 3. Accomplishing the long-term goal of wood products industry. (Table adapted from Salo et al. 2002, p. 10)

MAIN GOAL	FIRST LEVEL	SECOND LEVEL	THIRD LEVEL
Long-term industrial competitiveness	Strengthening of resource inputs	Science and technology research	Basic research
			Applied research
			Product development
		Other research areas	Economics and business research
			Environmental research
			Societal research
	Development of research collaboration	Collaboration between industry and research organisations	Extended collaboration within existing networks
			Creation of new networks
		Collaboration among research organisations	Extended collaboration within existing networks
			Creation of new networks

7 RESEARCH METHODOLOGY

The main interest in the study was in examining the quality and focal topics of scientific wood technology research in European institutions and finding new opportunities for research networking. To obtain an overall conception about the topics, different methods were combined. The research methodology consisted of qualitative elements, which included interviews, focus group discussions and a questionnaire study. *Figure 16* demonstrates the stages of the qualitative methodology employed in the study. The methodology is discussed in more detail in this chapter.

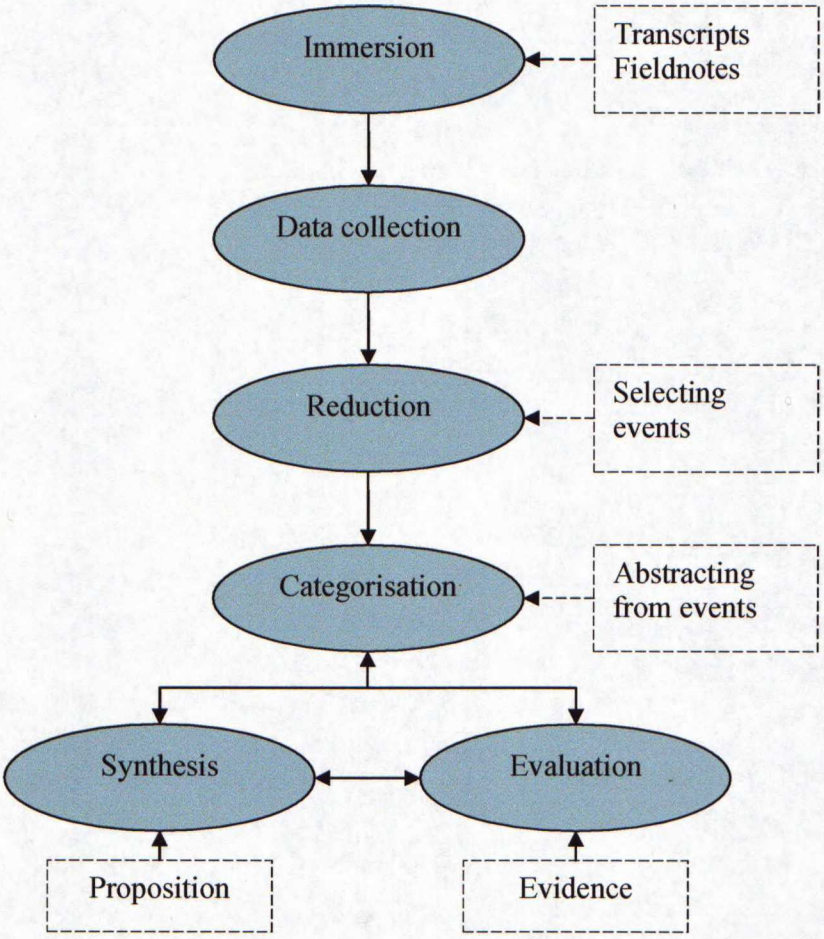

Figure 16. Stages of qualitative research. (Proctor 2000, p. 272)

7.1 DATA COLLECTION AND SAMPLING PROCEDURE

The data collection included background reading and informal discussions in the initial phase and in-depth interviews, a survey questionnaire and focus group discussions in the latter phase. First, the topics discussed in the interviews were formulated on the basis of the initial data collection. Second, the results from the interviews were utilised in defining an appropriate sample for the survey. Finally the results from the survey were thoroughly analysed in focus-group discussions.

Different data sources were used in the different phases of the study. The secondary sources of information that were used in the initial phase of data collection included literature, magazine articles, publicly available databases of research institutes and research institutes' www pages. The primary sources of information in the latter stage of the research included in-depth interviews and a questionnaire survey.

Institute-specific, detailed information was collected from the highest-level research institutes, which were the sample for the survey. The sample of the institutes chosen to the questionnaire study was a judgemental sample, which was based on the expertise of the interviewed professionals in wood technology research. The judgemental sampling uses experts' judging to identify a representative sample. *Figure 17* summarises the actions taken in the data collection and sampling phase of the study. (Aaker et al. 2000, p. 379)

7.1.1 Interviews

Semi-structured interviews are an effective way to gather a large amount of information. In such an interview the interviewer attempts to cover a specific list of topics, but freedom to discuss other relevant matters is provided. Even unexpected facts and attitudes can be pursued easily because of the open structure. *Table 4* summarises the reasons why this type of interview was considered appropriate in a qualitative research approach. (Aaker et al. 2000, p. 187)

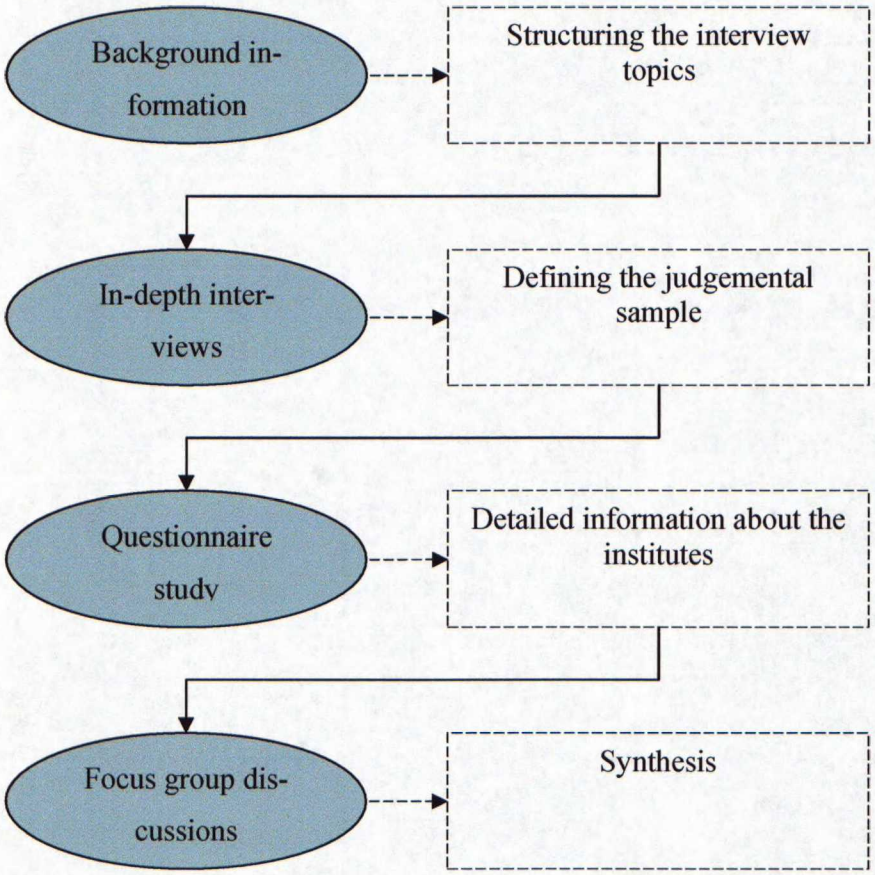

Figure 17. Data collection and sampling procedure in the study.

Table 4. Motives for using in-depth interviews in qualitative research. (Aaker et al. 2000, p. 188)

1.	Quality	The quality of information is high, because the interaction is direct and personal thoughts can be found out.
2.	Depth	The interviewer can go beyond surface answers and capture relevant and salient answers.
3.	Representation	The approach is representative because respondents are carefully chosen.
4.	Value	The respondent is likely to talk freely, which helps understanding the issue more profoundly.

The aim of the interviews was to outline the state of European wood technology research and to obtain professional opinions about the highest-level research institutions in Europe. The questions that were used as the basis for the interviews are presented in *Appendix 2*. The questions were formulated to

- Identify any focal areas of wood technology research areas in Europe
- Reveal any shifts in these trends in the near future
- Compare working methods of wood technology research in Finland and Europe
- Obtain relevant criteria of how to assess quality of research
- Understand the current manners of research networking.

The questions were sent to the interviewees beforehand by e-mail for acquaintance. In the interview the questions were used as the starting point for conversation but also related emerging topics, which were not included in the questionnaire, were discussed.

7.1.2 Questionnaire

The purpose of the questionnaire study was to complement the interviews and to deepen knowledge about individual research institutions. The aim was to gather institution-specific information about research resources, main research areas and current networking in wood technology. More specifically, the contents of the questionnaire covered institute-specific research resources regarding education and amount of personnel and graduates, high-priority research areas and their networking with industry and science.

Personnel-related research resources were asked because to some extent they reflect the reservoir of scientific knowledge in the institutions. On the other hand, all budget-related issues were omitted because it was anticipated they would have a negative effect on the willingness to response. Research areas were asked to examine whether any specific topics would emerge that were clearly more common than others. In asking the focus of research activities, the categorisation of "Key research areas in wood technology to year 2010" was utilised. This categorisation has been provided by HUT Laboratory of Wood Technology and the Technical Research Centre of Finland (VTT). The categorisation is presented in *Appendix 3*. Finally, the importance of different networking meth-

ods was examined and a chance to suggest any ideas of how to further develop them was provided.

The questionnaire used in the survey is presented in *Appendix 4*. Technically the survey was conducted as a www questionnaire. An e-mail asking to fill in the questionnaire was sent to the contact person in each institute and two weeks' time was given for answering. A reminding e-mail was sent four days after the deadline. An option of filling the questionnaire, printing it and returning by regular post was also given.

The available resources were asked with simple open questions. The questions concentrated on human resources and, in case of university research laboratories, teaching. In this section the respondents were asked to indicate the number of academic and non-academic employees as well as the amount of graduates.

The focus of research subjects and current networking was asked on an itemized-category scale with five labelled categories. The respondents were obliged to make a statement and not given a neutral choice. The scale was unbalanced, because there were more favourable than unfavourable choices. In addition there was no comparison of the respondent's present activities with other activities. *Table 5* summarises the features of the scale used.

Table 5. Features of the itemized scale used in the questionnaire. (Table adapted from Aaker et al. 2000, p. 278)

1.	Extend of category description	All categories labelled
2.	Treatment of respondent uncertainty of ignorance	Forced choice (no neutral point)
3.	Balance of favourable and unfavourable categories	Unbalanced
4.	Comparison judgement required	No

Finally, the questionnaire included two open questions about new ideas for research and industry networking and one question about any general comments.

7.1.3 Focus group discussions

Focus group discussion is an in-depth discussion of a particular topic: it is a process of obtaining possible ideas or solutions to a marketing problem from a group of respondents by discussing it. (Proctor 2000, p. 184) In this study the focus group consisted of R&D professionals who were representatives from Wood Focus Ltd. and Finnish wood products industry. The members of the focus group are listed in *Appendix 5*.

In the first phase the focus group was employed to plan the questionnaire and identify, which questions should be included in it. In addition the method and schedule for executing the survey were discussed in detail. In the second phase the focus group discussed and evaluated the results of the survey. Because the members of the focus group were R&D professionals themselves, the aim on the second stage was to discuss any surprising results from the survey and anticipate their meaning in the future.

7.2 DATA ANALYSIS

All the interviews were tape-recorded and transcribed. Some interviewees preferred not to have the recorder on and only written notes were taken in such cases. Analysing the transcripts from interviews and discussions involved three steps: reducing, categorising and synthesising the data. Reduction in this context implies to rewriting the transcripts to a more structured form so that the information content was clearer. Categorisation of data refers to locating individual themes that appeared repeatedly in the answers. Finally the pieces of data were integrated to present the main ideas on the whole. (Proctor 2000, p. 273)

The respondents were asked to indicate the emphasis of research activities by putting the three emphasis areas in order so that

1 = high priority
2 = second most important
3 = not important.

The respondents were given the freedom to indicate more than one area with the same number. The answers from this question were reflected to the types of research institu-

tions to discover whether a consensus about the terms used for different research activities exists.

The analysis of *research interest areas* was performed so that the choice for the first priority was given the value of 5, second the value of 4 and so forth so that

5 = high priority
4 = very important
3 = important
2 = slightly important
1 = not important at all.

The mean values for research interest areas were calculated. They were arranged from the highest value to the smallest to gain an overall figure how active the institutions are in different fields. A brief explanation of the statistical figures calculated from the data is provided in *Appendix 6*. The descriptive statistics related to the analysis are presented in detail in *Appendix 7*.

The conceived importance of different *ways of collaboration* was analysed by calculating the mean value for each statement in the questionnaire. The collaboration manners were arranged in order of mean values, so it could be examined which were the most and least important ones. The statistical key figures obtained from this analysis are presented in detail in *Appendix 8*.

Finally, the open questions were processed similarly to the open interview questions. The stages in data handling were reduction, categorisation and integration. The results from the questionnaire survey were then complemented with the opinions that emerged from the interviews. In addition, both the survey and interview results were reflected to the literature review to discover whether the gathered information supported the previously conducted studies or not.

In this survey, the non-responses were treated as blanks. Only in the question number five about high priority areas in research, the treatment of non-responses differed from the treatment applied in the other questions. If a respondent had rated some of the interest areas but left some points unanswered, the unanswered points were given the value

of zero. This was considered reasonable, because it can be assumed that in such cases the research area in question was totally irrelevant to the research organisation. However, in the cases of two respondents who had not answered the question at all, the answers were treated as they were blank.

7.3 LIMITATIONS OF THE METHODOLOGY

It should be noted that the perspective of the study is Finnish. Most of the ideas and opinions are presented from the Finnish point of view, because all the interviews were conducted among Finnish researchers. All the interviewees are, nonetheless, well-known and respected on the European level. On the other hand, the questionnaire survey was conducted among European research organisations. Therefore especially this part of the study concentrated on the European opinions and ideas.

The sampling procedure for the questionnaire survey was based on Finnish researchers' expertise. The attempt was not to have as many institutions as possible but rather include the highest-level institutes. The question is, however, whether mere judgement was enough to achieve this objective.

The response rate to the questionnaire, 53%, was satisfactory but not as high as anticipated. All organisations included in the sample were potential research providers for Wood Focus Ltd. Thus initially it was anticipated that each organisation should have been very highly motivated to answer to the survey. Against this background the response rate can be considered rather low.

Another problem was that the sample consisted of very different types of institutions. This complicated comparing the results, because different types of institutions have very different interests in their research activities, as was discussed in the literature part. As a consequence, the results should be should be regarded as indicative rather than conclusive.

The question formulation in the questionnaire was apparently too difficult in some questions. Although the survey answers were in general very well thought out and even the open questions were answered thoroughly, there were inadequate answers. Most re-

spondents did not answer to the question regarding the institution's interest group. It could be concluded that the question was either too self-evident or inadequately formulated.

In addition, some of the research areas had difficult topics and might have been understood in different ways. Also, there are many ways to categorise the research fields, which might have made it difficult for some to answer this question. Furthermore it should be noted that the last category, labelled "Approval, Certification and Testing", is actually not a research area at least according to the definition provided in the literature part. Furthermore, when comparing the answers and the categorisation of "Key Research Areas in Wood Technology to Year 2010" it can be noticed that some the topics mentioned in the open questions are actually the same as the ones in the ready-made list. This confirms the suspicion that some of the topics provided were formulated in too a difficult way.

8 EUROPEAN RESEARCH RESOURCES IN WOOD TECHNOLOGY

The following section introduces the results from the questionnaire study and synthesises the central arguments from the interviews. The most interesting results are emphasised and their significance discussed. First, the characteristics and research resources of the group of respondents are presented in detail. Then the question of what the strategic research areas appear to be and what they should be is tackled. Finally, the modes of collaboration between research establishments and wood product companies are examined.

8.1 RESPONDENTS

The interviewees were top Finnish wood technology researchers from VTT and the HUT Laboratory of Wood Technology. Their fields of specialty varied so that main research areas in wood technology, which are presented in *Appendix 3*, were covered. The total number of interviews conducted was 14. It is worth noticing that all the interviewees were Finnish researchers who nonetheless all had wide international experience.

In the questionnaire study the sample size was 55 institutions, of which 29 returned the questionnaire. The response rate in the survey was thus 53 %. The respondents' position in the research organisation varied: they were professors, assistants, heads of department, managing directors and research managers. Although the persons to whom the questionnaire was sent were mostly directors or heads of institute, in many cases the answering had been delegated to an assistant or equivalent. Also the group of institutions where the answers arrived from formed a very heterogeneous group, as their types and sizes varied. The next chapter discusses in more detail the differences between the research institutions.

8.1.1 Research establishments

The sample of the survey covered twelve European countries: Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Netherlands, Norway, Sweden, Switzerland and United Kingdom. The answers to the survey came from nine countries, which are presented in *Figure 18*. The figure also reflects the sizes of institutions in each country regarding the total number of employees in each country.

It should be considered that the respondents represent very different types of institutions, which distorts the distribution. Although the intention was to achieve only the number of personnel related to wood research, in some answers the number of employees reported was the total number of a building or other research institute. In these cases the number of personnel related to wood research is considerably smaller: wood research in these institutes is only one part of the overall research activities.

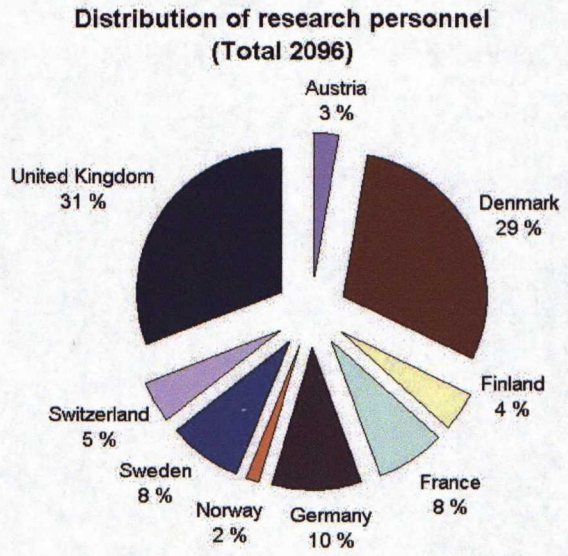

Figure 18. The amount of personnel in the respondent group by country.

Wood technology research can be organised in several different ways in a research organisation. The basic division is to academic and non-academic institutions. In this study only research conducted in universities was considered as academic research. All other research activities were regarded as non-academic. However, the definitions are ambiguous especially regarding polytechnic educational institutes and their research activities.

The issue of how to divide research into academic and non-academic was thoroughly discussed in the focus group conversations. The conclusion was that the educational systems is European countries are still different and thus the role of polytechnics is not straightforwardly comparable in different countries. For this study the previously mentioned categorisation was considered sufficient. It is important to notice that the definitions do not as such include any considerations of the type, quality or value of research conducted in the different types of institutes.

Referring to the above definition of academic and non-academic research, the organisations in the response group of the survey could be divided further into five distinct groups:

1. University, department or laboratory of wood technology
2. University, department or laboratory of civil engineering
3. Polytechnic
4. Other research institute, department of timber or wood
5. Other wood research institute.

Figure 19 shows how the answers to the survey divided according to the institute types. From the figure it can be noticed that the shares of answers from academic and non-academic institution were almost equal. Referring to the previous definition, 44% of all answers arrived from non-academic and 56% from academic institutions.

Apart from the above-mentioned division of research activities into different types of establishments, a related issue was discussed in the interviews. At the moment the starting point of research activities in any wood-related issue is clearly wood technology oriented. On the other hand there are research organisations in areas such as building

and environmental research, where the role of wood research is at the moment negligible. Deeper integration of research activities in different fields would promote use of wood in these areas. Integration here refers to that the role of wood should be strengthened in other areas of research.

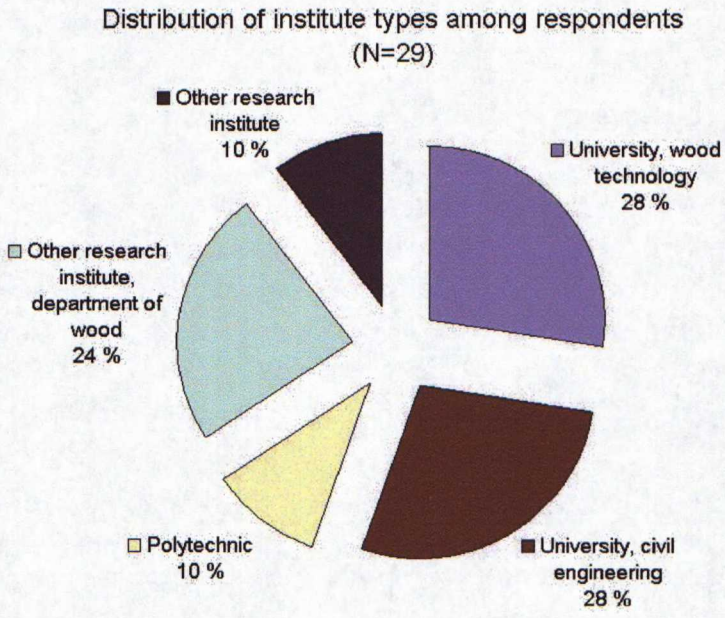

Figure 19. The group of respondents by institute type.

For example, as the manufacturing of wooden structures is shifting towards industrial production, the field of research is inevitably extending. In building research wooden structures should be analysed and developed similarly to and alongside with steel and concrete structures. The following quote from the interviews gives an example why the integration of different materials' research is such an important issue:

> "For example, in building industry the information technology systems are developing extremely rapidly. If the wood product systems are not adapted properly to the standards and systems in building industry, then we are again lagging behind the development. It is absolutely essential that wood research integrates to building research in a closer manner."

To provide appropriate products and product systems for building industry wood research activities should be integrated in other material research.

However, even among the researchers there are contradictory views of what would be the most appropriate way to arrange wood research. At the moment the prevalent arrangement appears to be that one research unit concentrates on a wide range of wood research topics. In addition there seems to be a border between research of wood and other materials in the research community. However, in certain research subjects a more non-conventional approach could be beneficial.

8.1.2 Human resources in research institutes

The respondents were asked to indicate how many scientific and technical employees are working in the organisation at the moment. The sizes of responded institutions varied from 4 to 650 employees. Most of the organisations belonged to the size group of 10 - 50 persons. *Figure 20* presents the distribution of answers regarding to the size of research institutions.

The size of the research institute and the share of academic personnel contribute to the quality of the research conducted: a certain critical mass of knowledge is required to achieve high-quality research results. In most organisations the majority of personnel had academic education, as *Figure 21* shows. The ratio of scientific personnel and technical personnel varied from 0,33 to 12. From the figure it can be concluded that there are considerable differences between the institutes: in some the amount of technical personnel exceeds the scientific personnel, whereas in some the number of academic staff is multiple the number of technical personnel. Even among the same types of institutions the ratio can vary significantly.

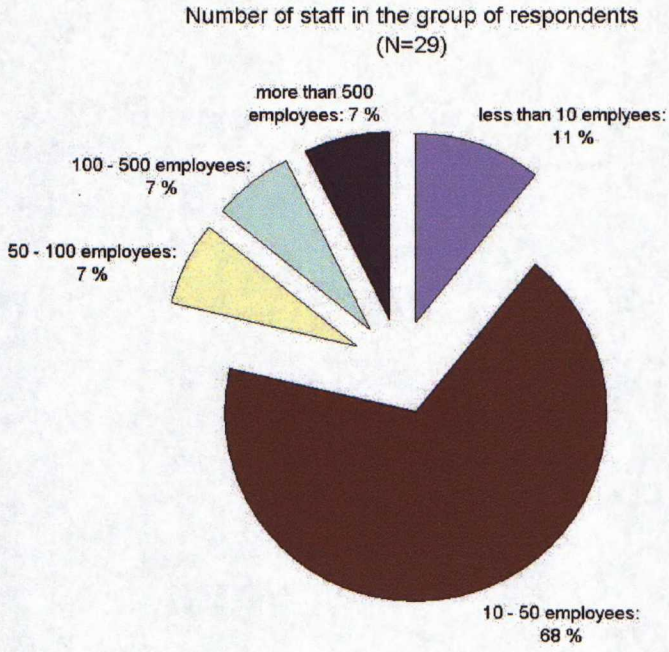

Figure 20. The size distribution of research institutes among respondents.

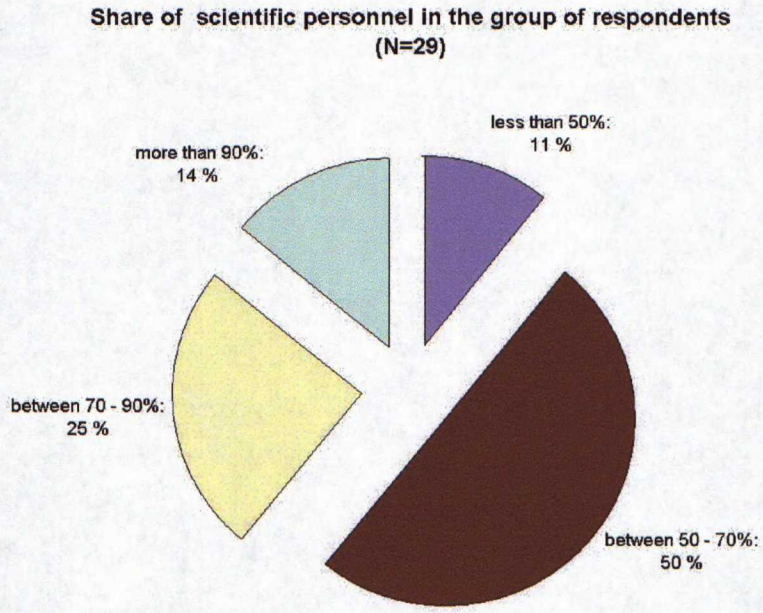

Figure 21. The share of academic personnel in research organisations.

8.2 QUALITY OF WOOD TECHNOLOGY RESEARCH

All interviewees emphasised very basic issues in determining the quality of wood technology research. Naturally the same criteria apply to evaluation of research in any field. One interviewee captured the essential conditions for research work to succeed:

> "That the work is planned well in advance, the research methods that are to be used are well considered and thought-out, the research methods are standardized or otherwise clearly individualized, the results are analysed statistically and that the results are reproducible."

However, there were some deficiencies that were considered to be a problem particularly in wood technology research. One issue that was heavily criticised was the poor conducting of the initial background work and collection of information. The interviewees stated that the researchers do not study the previous research work thoroughly enough and thus waste resources. As one interviewee aggravated:

> "Everybody starts from the scratch as if previous studies did not exist! The most serious mistake today is that researchers do not read the previous research reports."

The focus group emphasized that measurement data certainly exists from different fields, but it is not readily available for further use. There would be potential to analyse the data further and in more detail. In other words the current practise is such that when a new project starts, data collection also begins from zero. The challenge is how to save and provide measurement data from projects for further utilisation in modelling. One practical tool could be that it would be obligatory in project funding applications to determine what how a measurement data bank is collected and how it could be utilised in further projects.

8.2.1 Acquisition of necessary resources

One anticipated problem concerns the use of modern research equipment. The equipment is becoming more and more expensive and it is impossible for most of the establishments to procure them. Especially experimental research, which requires specific

instruments, is becoming more problematic to conduct. In the future efficient use of such equipment will require coordinated and well-functioning cooperation between research institutes. Another option would be to develop operations models where several institutes would jointly purchase a resource that none of them could purchase individually.

8.2.2 Dissemination of research results

As for research results, research needs clear objectives in industrial applications and there has to be a link to applied research and further to basic research. The results should have novelty value and they must be either applicable to practise or exploitable as basis for further research. It is important that the work is challenging so that the result cannot be anticipated clearly beforehand.

One criterion for high-quality research work is that it is reported in international research publications. There are not many such papers in the field of wood technology, and getting an article published can be both timely and difficult. In addition, different types of research establishments have very different interests towards publishing research results. First, in many academic institutes the situation is such that there are no rewards or other motivators to encourage publishing. Thus the interest towards publishing depends only on the researchers' appeal to make their name more widely known. Second, when considering industrial research, the research institutes are most often not allowed to publish the results. The conflict lies in that research should not be too closed in a specific community, because enough mechanisms for knowledge exchange and transfer must remain.

Another measure of research quality is the amount of high-level dissertation theses prepared in a research institute. Here the traditions are different in Finland and other European countries. For example, the topics of doctoral theses are very narrow in many European countries. On the other hand, the themes for theses prepared in Finland have been very wide. One interviewee indicated the significance of doctoral studies as follows:

"The amount and level of dissertation theses are very competitive in Finland. In this context it must also be considered that doctoral level education has an outstanding weight in the European research forums."

8.2.3 Critical mass of knowledge

One of the most frequently mentioned arguments in assessing the quality of research was the so-called critical mass. The basic idea is that combining knowledge and skills in a research area is a precondition for top-level research. The combination and accumulation of knowledge and skills ensure continuity of research work and enable high quality research. It is worth attention that the critical mass does not develop by itself but it must be developed purposefully. To examine how the concept of critical mass realizes in wood technology research, the number of high-priority research topics related to the number of personnel in the institutes was examined from the answers to the questionnaire survey.

The ratio of personnel and high priority research areas mentioned in the answers varied from 0,4 to 32,5. *Figure 22* illustrates the wide variation of the ratio in the institutions. There were two very large institutes, where apparently a large group of researchers can be nominated to a certain research topic. On the other hand, there were some institutes, which had named very many high priority topics even though their number of personnel is small, only a few people. Such cases suggest that the scarce resources of the institute are scattered to too many research issues. However, from the figure it can be noticed that most of the institutes belong to the group where the ratio of personnel and high priority interest areas is between 2 and 5.

The results expose the problem of determining the adequate size of a well-functioning research group. Although there is a consensus that a critical mass of knowledge is required to ascertain high-quality research, the problem remains of how to accurately determine the concept of critical mass.

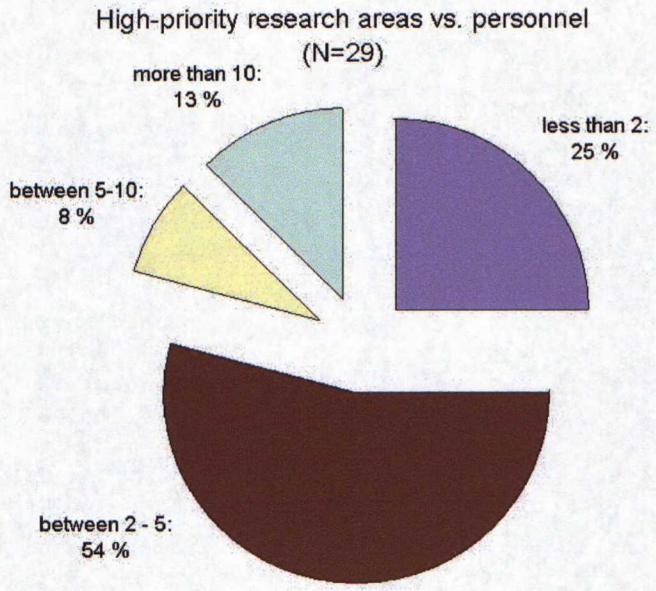

Figure 22. The number of high-priority research areas mentioned compared to the number of employees in the research institutions.

Another trouble is that at the moment research in wood technology is strongly personified to certain researchers and university professors. Because they hold much of the critical knowledge, continuity of research is at stake when these key persons change employer. This issue appeared frequently in the interviews, and individualized examples of the phenomenon were mentioned. As part of the same phenomenon, there are persons who run or are in charge for more than one research organisation. As long as the knowledge is in a way restricted to a few people, it cannot be claimed that a critical mass exists.

8.3 STRATEGIC RESEARCH AREAS IN WOOD TECHNOLOGY

When considering most European countries, wood products industry and wood technology research are not significant issues from the national economics' point of view. As a consequence, Finland has an opportunity to act as a trendsetter and Finnish researchers

could achieve leading positions in applying wood technology research into practise. However, to be able to achieve this position the Finnish researchers should gain more credibility and weight for their opinions in international arenas. In addition this requires a continuous process so that eventually it would be possible for the Finns to affect international norms and standards regarding the use of wood products.

The focus group discussions raised the question of fashionable research areas. It appears that on European level some research topics can develop to being more fashionable and desired than others. These were described as areas where "everybody is doing research". Such enthusiasm can develop in a relatively short period of time, but without anyone thoroughly considering the longer-term strategic objectives. The same phenomenon was mentioned in the interviews: the interviewees also pointed out that the fashionable research topics cannot be regarded as focal interest areas. One interviewee summarised this phenomenon:

> "Many issues that are currently studied are not interesting from the viewpoint of gaining economic benefits and developing wood products. Because of the academic traditions in European wood research, research topics remain the same and nobody considers the practical implications of the research."

From the strategic point of view the long-term strategic objective lacks completely from research activities of this nature.

The fashionable research interest areas are not necessarily the same research areas that wood products industry and funding bodies would appreciate. The problem appears to be how the needs and wants of industry, funding instances and research institutes could be communicated effectively. At the same time there are areas that industry and even some researchers consider important, but nobody is currently active in those fields.

Apart from the fashionable research issues, research activities in wood technology are very scattered in Europe and there is no clear emphasis in it at the moment. This conclusion could be drawn on the basis of the interviews. Typical comments were:

"The first though that comes into mind is whether any emphasis areas exist in wood technology research."

"If only I knew what the emphasis areas were!"

In the focus group discussions COST actions were criticised for not being based on the needs of wood products industry but on researchers' interests. On the other hand the actions create sustainability, because they bring together researchers who work continuously together. Thus COST actions are really about researchers' cooperation, they lack the industrial point of view. There should be more representatives from industry in COST actions and industrial perspective should be considered when selecting the topics. Further information about the COST Actions is presented in *Appendix 9*.

The survey data was handled to reveal whether in this group of research organisation any research topics would be emphasised. The related statistical information is presented in *Appendix 7*. The profile of the entire group of organisations is presented in *Figure 23*. For clarity the results under each of the nine main titles presented in *Appendix 3* were combined. The figure shows the share of institutions that rated the topics to very important, that is of importance of 4 or 5. From the figure it is obvious that in this group of wood technology research establishments, *research activities concentrated on three areas*:

1. Structural systems and joints
2. Approval, certification and testing
3. Durability of wood and wood products.

On the other hand, the *research areas of the least interest* were:

1. Living with wood and ecology of wood products
2. Modelling and optimisation of wood chain
3. Wood science and material engineering.

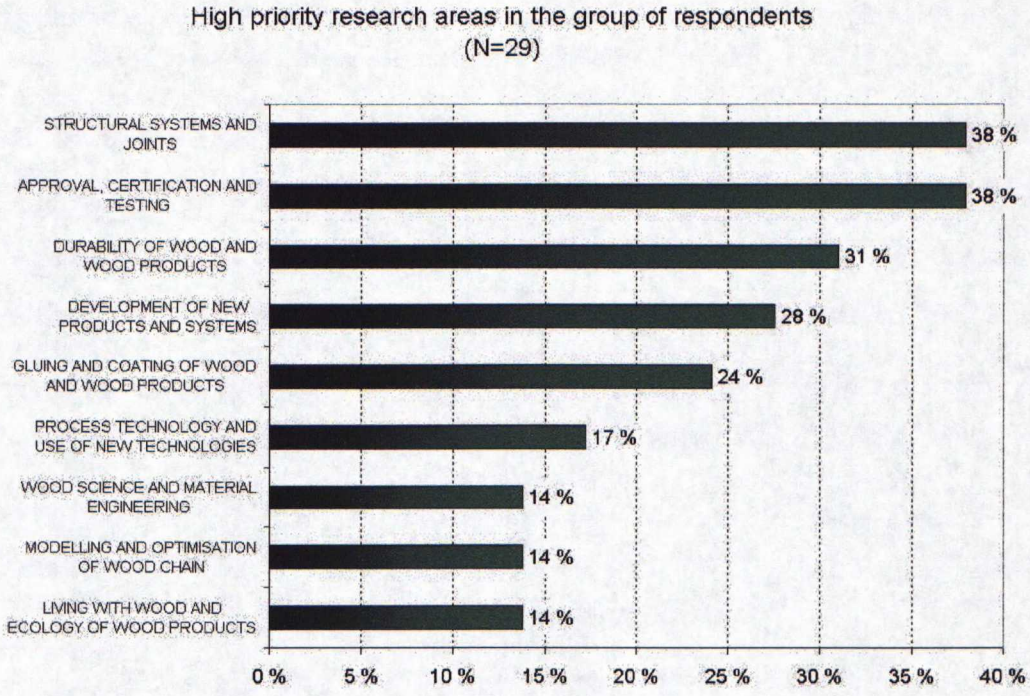

Figure 23. Outline of the most important research areas among the respondents.

Referring to the individual research topics from *Appendix 3*, the three specific research topics that were most frequently mentioned to be *high-priority* were:

1. Testing
2. Mechanical and physical performance of wood-based structures and joints
3. Product approval and certification.

The three individual topics that were the *least interesting* were:

1. Maintenance and life cycle cost of wood construction
2. Panel products processing
3. Chemistry of wood and polymers.

To analyse the interest areas further, the overall mean values for each main topic presented in *Appendix 3* were calculated. *Figures* from *24* to *26* illustrate how these varied in different types of research institutions. For this purpose the respondents were divided in to three groups: academic wood research laboratories, academic building research laboratories and other, non-academic research institutions. As could be expected, there were distinctions in the different groups regarding their high priority research areas.

In academic wood research laboratories the significance of wood science and material engineering was emphasised. In academic building research, the structural systems and joints were, as could be anticipated, the focus area in research. In non-academic research approval, certification and testing were the most important activities. Another distinct feature in this group was the importance of gluing and coating of wood products.

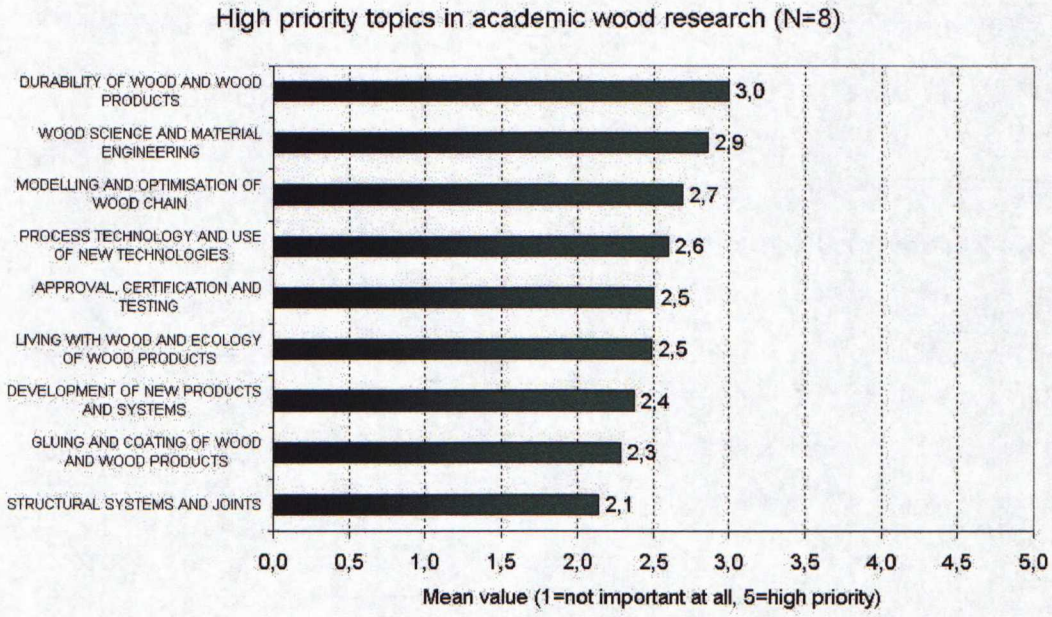

Figure 24. High priority research areas in academic wood research laboratories.

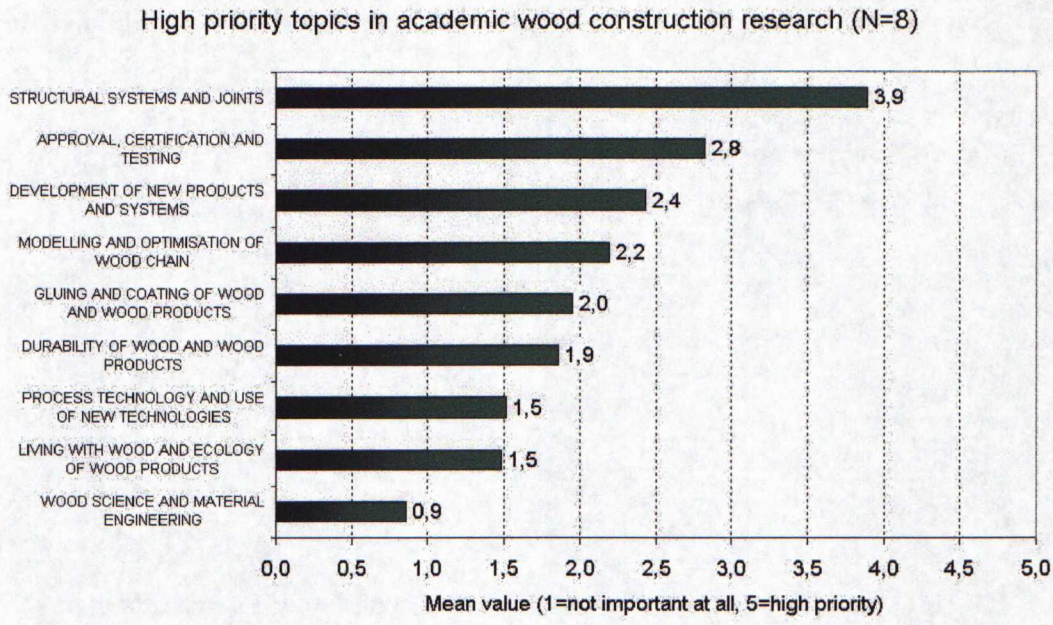

Figure 25. High priority research areas in academic research laboratories for wood construction.

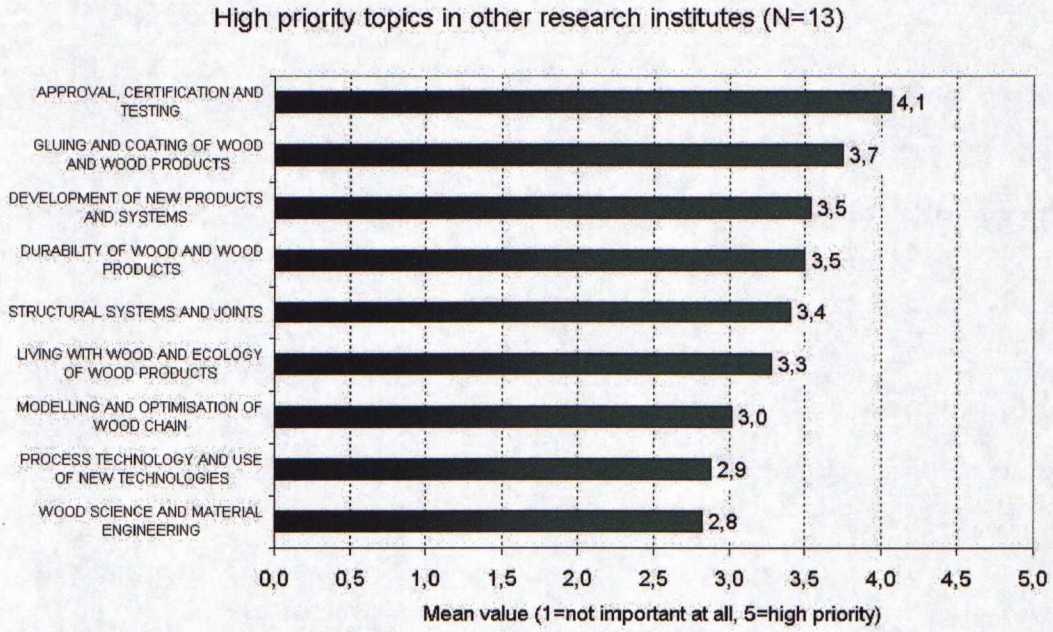

Figure 26. High priority research areas in other than academic research laboratories.

From the open questions in the survey numerous other research interest areas emerged in the group of respondents. All mentions were occasional and some very narrow, however. Thus it can be concluded that the categorisation used was appropriate and covered the research topics widely enough. Other high priority research areas than those mentioned in the questionnaire were:

- Wood fibre ultra structure
- New appliances for wood based products
- Wood textile compounds and joints
- Moisture properties of wood
- Implementing EU regulations for the practical use of wood products
- Characterisation of wood resources
- Modelling of native wood and fibre properties in trees and on a forest stand and regional level
- Non-destructive testing methods of wood
- Knowledge and technology transfer
- Textile coating for outdoor application
- Prediction of service life
- Optimised bucking with on-board computers
- Machining and development of tools
- Technical wood profiles by means of thermo-mechanical processes
- International standardisation
- Wood procurement with respect to demand and value recovery
- Market surveys
- Densified and thermo wood and their applications
- Supply chain and logistics
- Light-weight structures
- Composite structures
- Modelling of wood and timber damage.
- Quality management and control for light- frame timber houses
- Strategic marketing in wood industry
- New marketing designs in wood industry.

The rather exhaustive list that was derived from spontaneous answers further supports the conclusion that there are numerous research topics in European wood technology research.

8.4 EMPHASIS OF RESEARCH ACTIVITIES

To examine the emphasis of research activities regarding the type of research establishment, the group of respondents was divided into two: academic and non-academic institutions. *Figure 27* shows how many times the different emphasises were mentioned as high priority emphasis in both groups. Surprisingly, in the academic institutions applied research was mentioned most frequently as the most important. In addition different emphasises did not distinguish in the two groups of respondents: all received very similar remarks of importance.

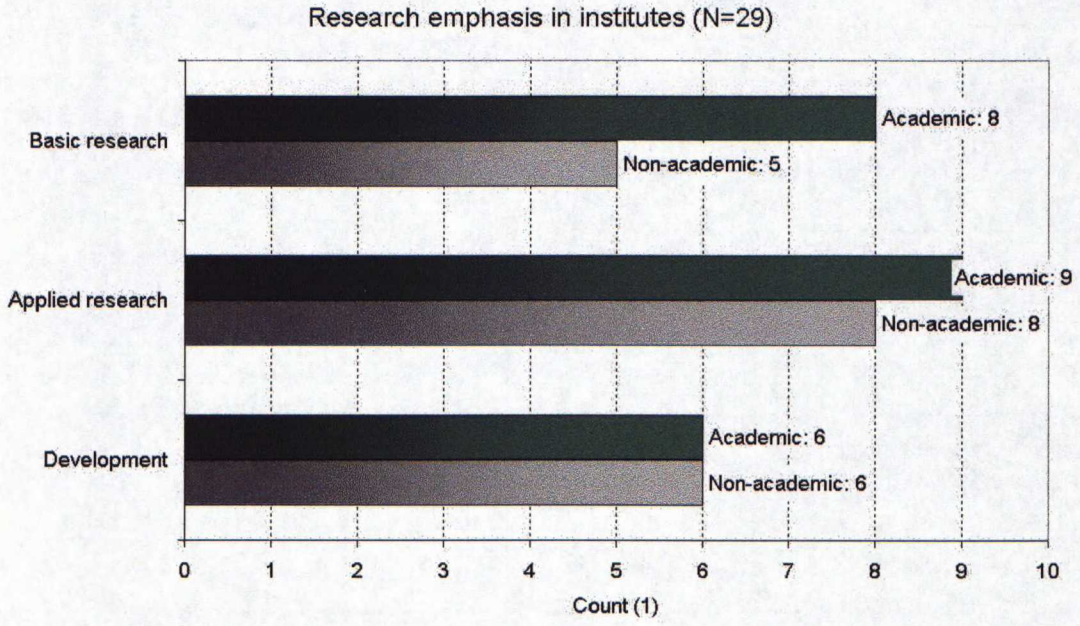

Figure 27. Emphasis of research activities in academic and non-academic research organisations.

This finding does not follow the traditional model of research emphasis in different types of organisations. It is possible that the traditional role of academic research is changing and the emphasis is not on basic research any more. On the other hand, the result may indicate that there is no common language in defining the character of research activities. In other words even research professionals may put different meaning to the same topics.

This vagueness of using different concepts also indicates that the different research areas overlap and have no clear boundaries. As one respondent noted:

> "The nature of our research is between basic research and applied research, as defined in your way. We call it applied basic research."

The overlapping nature of the research activities has to be carefully considered in communication to avoid misunderstandings. In communication special attention should be paid to giving detailed enough information.

8.5 RESEARCH COLLABORATION

8.5.1 Cooperation among research institutes

Figure 28 presents the results from the question regarding collaboration between research institutes. From the figure it can be concluded that informal contacts between research institutes are the most important ways of collaboration. Joint research projects between organisations were regarded equally important. On the other hand, joint usage of equipment and exchange of personnel between institutes were regarded as less significant in research cooperation.

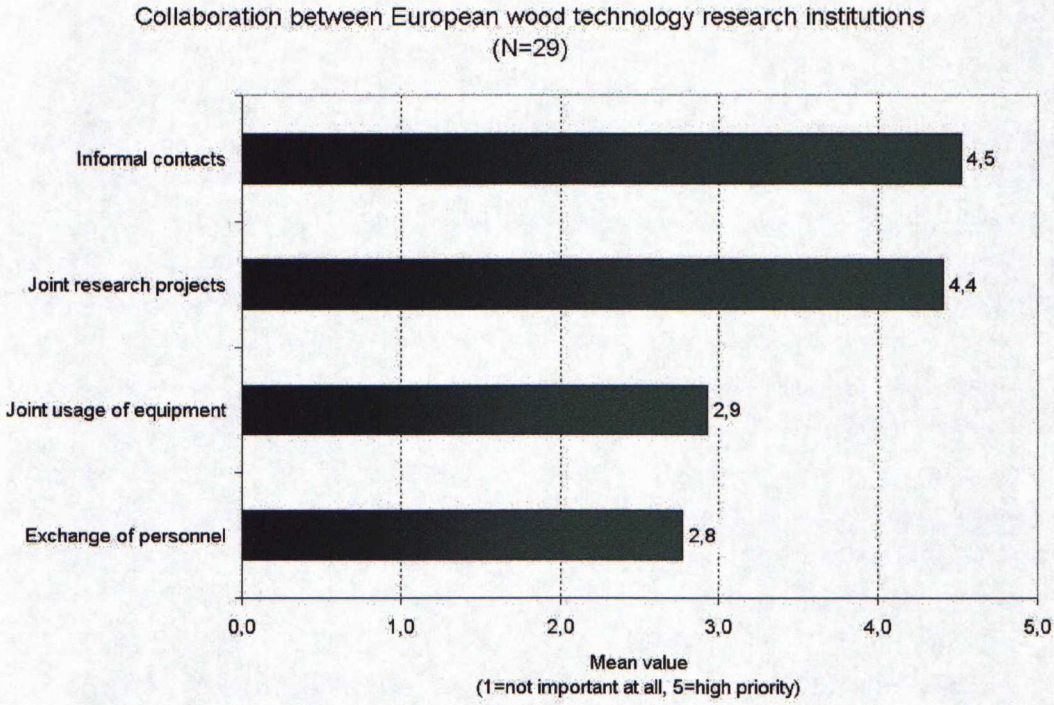

Figure 28. The most important ways of collaboration between wood technology research institutes.

To summarise the open question asking prospective cooperation with other research institutes, there was a strong motivation among the respondents to strengthen collaboration between European wood technology research institutes. A variety of proposals emerged from the answers. Participating in joint research projects and developing well-functioning relations were frequently mentioned as suitable methods to promote networking and develop stronger networks or clusters. Research networks could be established by forming research alliances and consortia related to a certain project or topic related.

Many establishments have already realised the need to develop better functioning research networks and are actively working to promote networking. Especially the larger institutes stated that they are already constantly developing their co-operations with other institutes. Interestingly, experience exchange was mentioned as one means to develop collaboration in the open questions and the interviews. Thus, although not conceived very important at the moment, personnel exchange could have a more prominent

role in future research networks.

The respondents identified certain specific research topics that would require special attention when joining in networks and project groups:

- Wood and pulp fibres' structural properties
- Wood chemistry
- New concepts and aspects of wood's and wood products' biological decay
- Protection of wood and wood products
- Non-destructive testing
- New glued products
- New wood-fibre composites
- Seismic loading of wooden structures.

Several already established frameworks and research programmes were mentioned, which the respondents regarded as well functioning in enhancing research networking. InnovaWood gained special attention:

> "Active participation in InnovaWood cooperation is linking us to all relevant wood technology research institutions in Europe."

Other programmes mentioned were the EU 6th framework programme, COST, projects funded by the EU commission, national R&D programmes in general and Nordic R&D-programmes especially.

To summarise the interviews, boundaries between research areas should not be too strict and the search for research partners should be extended to new research establishments. Examples of such extended networking are expertise in fibre properties, which could be found in pulp and paper research and knowledge in system building, which could be found in research of construction processes and civil engineering. In addition, it is worth noting that top expertise about certain areas does not exist in Europe. For example, wood system building has longer traditions and wider application areas in North America. Thus European networking in wood technology research is not enough; the scope of seeking collaboration partners should be global.

8.5.2 Interaction between science and wood products industry

In general, European wood technology research has very strong academic traditions. The Finnish approach that industry and research are working in close cooperation is unfamiliar in many European countries. The following quote summarises the theme from the interviews:

> "My opinion is that when considering research in Europe, it is not nearly as industry-oriented in most of the countries as it is in Finland. There is more work which starts from the researchers themselves and begins with "let's invent a good research topic"."

There is wood technology research in many instances in Europe, but it is often separated from practise. Because strong cooperation has not been the shared model of operation, building functional networks needs to begin by searching for suitable partners.

Figure 29 presents the results from the question regarding collaboration between research institutes and wood products industry. The figure shows that the importance of different collaboration methods with wood product companies was evaluated similarly to those between research institutes. Again, informal contacts were conceived as the most important ways of collaboration. Research conducted for companies was also regarded important. Yet again, provision of equipment and exchange of personnel between institutes were regarded as the least significant in research co-operation.

As was mentioned previously, the traditions in European research do not support close cooperation between publicly funded research institutions and wood products industry. However, the respondents regarded such collaboration as a positive event and suggested several approaches that could be applied in developing it in the future. In this respect it can be stated that Finland has been a forerunner, because the Finnish tradition supports close collaboration between wood products industry and research establishments.

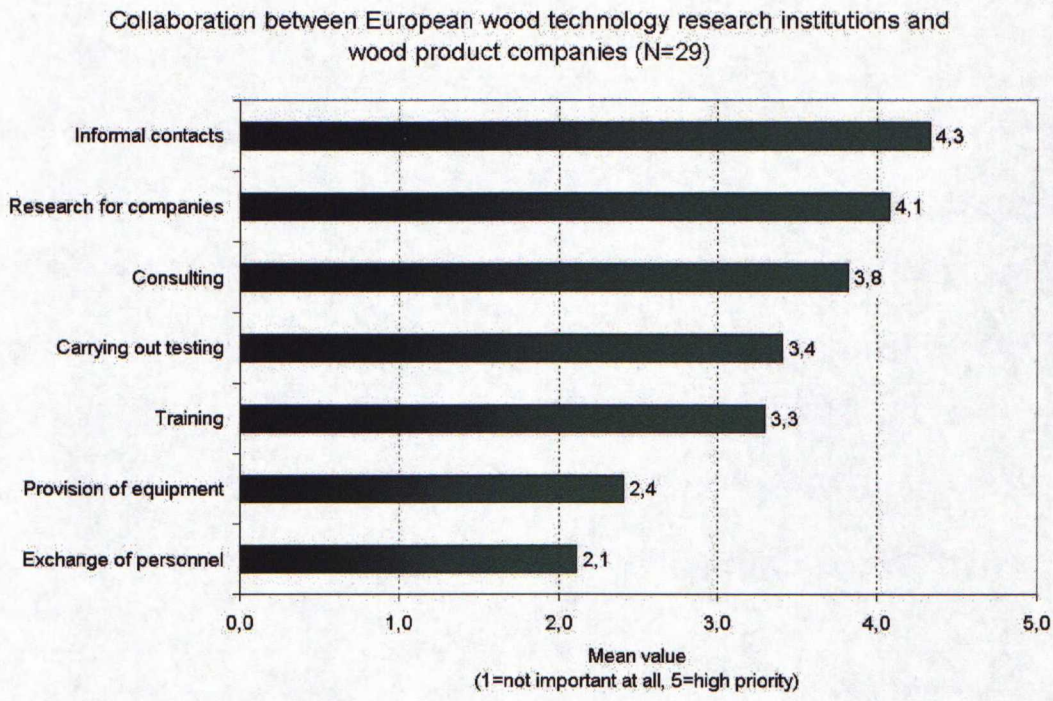

Figure 29. The most important ways of collaboration between wood technology research institutes and wood product companies.

Among the respondents there was a desire to conduct more research and development in joint projects with the companies and to do more consultant work for the companies. The institutions were also interested in cooperation with industry associations. It was also stated that the cooperation should take place in both national and international level. The academic research institutes especially appreciated industry funding in research projects. However, the industrial cooperative projects should fit in the research strategy of the institutes as well, not only to the companies' strategy.

The different types of research establishments have very different possibilities to contribute to industrial cooperation. The non-academic institutions aim at presenting companies profitable opportunities in product investigation, development and product approval testing. Profitable here refers to such potential for better profitability in future business that the companies cannot reject the offer.

The non-academic institutions also regarded their relationship with the industry plainly as a business-to-business relationship. In other words, these research institutions provide services such as testing, certification or training to their potential clients. On the other hand, one proposal suggested that future projects could include establishing background documentation for regulations and acceptance.

As for some publicly funded research institutions, cooperation with industrial companies is sometimes restricted to topics of general interest:

> "Because we are obliged to carry out wood research in such a way that it is always prepared to give advice to the Ministry in political decision making processes, industrial partners must be willing that we publish the results of the contracted research. If such precondition is met, we are very open for co-operation with the industry. "

The interviews revealed another crucial argument: the interaction between science and industry is difficult due to different orientation and mindset. The different starting point - business orientation versus academic orientation to be exact - in industry and research causes conflicts in communication. The conflict easily leads to the client being dissatisfied. Some researchers already recognise this problem, but there are no practical tools to overcome it yet.

The following research topics were mentioned as of particular interest in industry collaboration:

- Gluing of new products
- Quality control (non-destructive testing)
- Light-weight structures
- Composite structures.

9 CONCLUSIONS

The importance of wood products industry varies in different European countries. Depending on the traditions and the products, production of wood products can be perceived either as part of agriculture or part of industry. Thus the basis for discussion about developing wood products industry and research on European level is very diverse. The concluding chapter discusses what activities should be taken to tackle the problems related to achieving the strategic objectives of the European wood products industry. It also emphasises the importance of efficient use of research resources as a prerequisite for future development processes. Finally the issue of change management and related obstacles are examined shortly.

9.1 ACHIEVING THE STRATEGIC OBJECTIVES

At the moment the structure of European wood products industry and related research activities are scattered. As a consequence, the strategic situation in the industry and research is ambiguous: there are many actors with different backgrounds, traditions and interests who lack a functioning network for efficient communication. Thus, as a starting point for future development, it should be perceived that the current situation in wood products industry does not meet its strategic objectives. This is why a strong *common European vision* in wood products industry and research is needed. What is even more important is to persuade the different actors in wood products industry and wood technology research to agree on common goals.

The problems in achieving the strategic objectives of the wood products industry derive from the variety of actors in the field. In different countries the production concentrates on different products and the size and number of companies vary. As a consequence, also the roles of innovation and R&D in the companies' own strategies differ. The varying objectives and interests of individual companies complicate finding common views for the industry on the whole. In general it can be stated that in wood products industry R&D is strictly controlled, there is no or little room for intuitive activities.

By stating high-level objectives such as the Vision 2010, wood products industry has been attempting to strive for mutual modes of operating. These objectives derive from the need for better directed R&D in wood products industry. This is the only manner to build a knowledge reservoir so that results from R&D can be achieved and utilised commercially in a short period of time. This is why in this context the key technology implementation should be regarded more as a *management process* of research activities and dissemination of results. Thus there is a need for directed research work, but defining and agreeing on the appropriate focus areas can be problematic.

9.2 Utilising research resources efficiently

Generally speaking, in EU research funding is directed towards other fields than wood technology research. Thus the appropriate utilisation of research resources in wood technology is a central issue. At the moment there are several obstacles that hinder developing wood technology research efficiently, all related to the question of how to use the available research resources more economically. The basic problem is that resources in wood technology research are scattered and there are no clear, conjointly agreed focus areas.

The first important issue is the initiation of wood technology research projects: how are the decisions about resource allocation made? The allocation should be a controlled process deriving from the needs of the industry. At the moment, however, it appears that in many cases research topics emerge by coincidence, based on the impression that all others are also active in that field.

Because the activities are different in different types of establishments and there is no common view of prioritising the research topics and ways of operation, the basic question in this situation is how to develop better-functioning co-operational models? Knowing the importance of the existing informal contacts in networking, extending the network requires developing functioning and close relationships with *new* institutions and persons. Outside contacts are especially important for small research groups to obtain the necessary critical mass for high-quality research.

On the other hand large European projects such as the 6th Framework and InnovaWood have not stabilised their position yet. Again, in these projects the different parties have their own interests, which might be conflicting. In such European projects bureaucracy is a serious problem, in both the applying phase and during the project itself. The current practise favours large research units, because whether a research unit has the required resources to apply for European projects depends on the size of the research unit. For smaller units the cost of working hours spent in paper work quickly becomes intolerably high. Because any research work is expensive, the small units do not have many options where to get financial support.

9.3 MANAGING CHANGE

Changing the traditional research manners is a slow process. Change management as a process in this field requires recognising

1. The special features of the business environment of wood products industry
2. The development process so far
3. The potential collaboration partners.

Another important issue is changing the viewpoint from researcher-based to customer-based. At the moment the main subject and driver in developing stakeholders' networking is how to increase the amount of wood used in different applications. However, this can only be achieved by influencing the end users' attitudes and buying behaviour towards preferring wood to other materials. Thus it can be stated that in many cases a genuine customer-orientation still lacks from the activities of wood products industry and research activities.

There are a few countries that have been active in connecting wood technology research with industry's operations for a long time. Of these countries Finland, other Nordic countries and Austria deserve special attention. In these countries wood technology research is highly developed, because the following conditions are met:

- Forest based industries have a significant role in the national economy
- Forest research has traditionally had close connection to industrial and aca-

demic research

- There is a coherent educational system which enables well-functioning communication
- There is a long experience in wood technology programs.

As a result it could be stated that Finland, other Nordic countries and Austria should have an active role in developing wood technology research and its modes of operating on European level.

10 SUMMARY

As a consequence of internationalization, the companies acting in wood products industry need to search mutual modes of operating and uniting R&D resources. This study has provided a basis for the process of advancing research networking in wood technology in European Union. The first step in was to introduce the current research topics and resources in wood technology research in Europe. The main interest in the study was in examining the quality and focal topics of scientific wood technology research in European institutions and finding new opportunities for research networking.

The research methodology consisted of different qualitative elements. First, based on the initial data collection, topics discussed in 14 interviews with Finnish wood technology researchers were formulated. Second, the results from the interviews were utilised in defining an appropriate sample for a www-based questionnaire study. The survey was sent to 55 institutions in 12 European countries, and the response rate was 53%. Finally the results from the survey were thoroughly analysed in focus-group discussions.

The results imply that the most important research areas in wood technology are structural systems and joints, approval, certification and testing and durability of wood and wood products. However, it appears that there are certain fashionable research issues, where many researches are active, but these are not the same research areas that wood products industry and funding bodies would appreciate. Apart from the fashionable research topics, activities in wood technology research are very scattered in Europe and there is no clear emphasis in it at the moment.

In the future the European research community needs to participate in an interactive process to discuss common goals in research and development projects and policies. The results suggest that there is strong will among the research institutes to interact and cooperate closely with the wood products industry. This creates a solid foundation for developing a sustainable research policy in wood products industry.

The research results also imply that there are several areas where wood products industry and wood technology research should shift away from the traditional modes of operation. In general the results indicate that there is an increasing requirement to develop

closer collaboration networks among wood technology researchers and industry. On the other hand the search for research partners should be extended to outside Europe and to areas such as building research and environmental research. Thus there is a preference towards breaking the traditional patterns in research collaboration.

There are contradictive opinions about how wood technology research should be arranged to achieve the best results. At the moment in Europe wood technology research is strongly personified to knowledgeable experts, who master their own field of specialty. On the other hand there are fashionable research areas where many organisations are active. The challenge is to develop customer-oriented research so that there is a genuine will to achieve industrially significant results and to commit to long lasting research work. Here the question of how to achieve critical mass to ensure high quality in research requires careful consideration.

At the moment it appears that there are no distinct research topics that could be described as the focal points of European wood technology research. Because the research resources in wood technology are restricted, it would be important to arrange research activities efficiently and concentrate on the strategic areas. The research organisations should be able to concentrate on their core competences and cut the number of research topics. The central challenge is how to reach a common view of what the strategic research areas actually are.

Personal contacts and informal communication are very important ways of co-operation, so special attention should be paid to developing them. Many institutions have already realised the need to develop better functioning research networks and are actively working to promote networking. Even though the European traditions do not support networking between industry and academia, the results imply that a change is taking place: at least the importance of such collaboration is recognised.

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Registered associations:

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Other collaboration partners

Finnish ThermoWood Association

Nordic Timber Council Ab

For further information about Wood Focus Ltd. and its operations, see the homepage at http://www.woodfocus.fi/

1. What are the focal areas of wood technology research in Europe at the moment?

2. What kind of changes can be anticipated in the focal areas and working methods of European wood technology research in the next five years' time?

3. What are the core areas of your wood technology research?

The next questions are related especially to your wood technology research:

4. What are the leading research institutes of wood technology in Finland and in Europe? What are their most important areas of expertise?

5. What are the most significant European cooperative projects at the moment?

6. What criteria must high-quality wood technology research meet?

7. What is the position of Finnish wood technology in Europe?

8. How do wood product companies and research institutes collaborate in Finland and in Europe? Can you mention some examples?

1. Wood Science and Material Engineering

Chemistry of wood and polymers

Chemical modification

Theory of wood drying

2. Durability of Wood and Wood Products

Biological deterioration and damages

New protection concepts

3. Adhesion, Gluing and Coating

Adhesion wood to wood and wood to other materials

Gluing technologies

Surface technologies and coating

4. Structural Systems and Joints

Mechanical and physical performance of wood-based structures and components

Design and calculation methods and tools

Fire performance and fire safety

Reliability analysis

5. Process Technology and Use of New Technologies

Wood drying

Measuring and Control Technologies, Machine Vision

Simulation of production systems

Process control and automation

Panel products processing

6. Development of New Products and Systems

Modified wood products

New wood-fibre-based composites

Functional coatings for wood-based products

New wood-based product systems

Low-energy wooden houses

7. Modelling and Optimisation of Wood Chain

Interaction of technology and business

IT tools for simulation, management and optimisation of wood chain

Logistics and networks in delivery and marketing

Development of wood construction process

Market analysis of wood products and wood construction

Technology strategies, technology forecasting

8. Living with Wood and Ecology of Wood Products

Environmental impacts of use of wood and wood products

Emissions, indoor air

Maintenance and life-cycle cost of wood construction

Customer satisfaction with wood products

Recycling of wood

9. Approval, Certification and Testing

Product approval and certification

External quality control, inspection

Testing

Development of testing methods

EUROPEAN RESEARCH RESOURCES IN WOOD TECHNOLOGY - QUESTIONNAIRE

In **open questions** write the answer to the space provided. In **multiple choice questions** select the option that is relevant to your research institution. Please note that the fields marked with an asterisk (*) are compulsory. The questionnaire will be sent only if these fields are answered. Send the completed questionnaire by clicking the **"Submit"** button at the bottom of the page.

Thank you for your co-operation!

RESPONDENT

1. Contact information.

*Name:

*E-mail address:

*Organisation:

*Department:

Respondent's position on the department:

Please indicate the interest group of your institution:

- University *(please go to question 2)*
- Polytechnic *(please go to question 2)*
- Other non-university research institution *(please go to question 3)*
- Other *(please go to question 3)*

If "other", please specify the interest group:

PERSONNEL

2. How many degrees were completed in your laboratory or department during the year 2002?

Basic degree = Bachelor's or Master's degree.

Post-graduate degree = Licentiate or Doctoral degree

Number of basic degrees completed:

Number of post-graduate degrees completed:

3. How many full-time employees are there in your institution at the moment?

Scientific personnel = Research personnel having an academic degree.

Technical personnel = Everyone else contributing to research projects in a technical aspect, such as technicians or technical assistants.

Number of scientific personnel:

Number of technical personnel:

RESEARCH AREAS

4. What is the emphasis of research activities in your institution? Please put the following in order from 1 to 3. If some particular area is completely irrelevant to your institution, please leave blank.

1 = priority
2 = somewhat important
3 = not important

Basic research = Fundamental science that involves work of a general nature intended to apply to a broad range of uses or to a new knowledge about an area.

Applied research = Application of science that involves the use of existing scientific principles for the solution of a particular problem.

Development = Application of science that involves the use of existing scientific principles to overcome a technical problem associated with a particular product.

- Basic research
- Applied research
- Development

*5. Below is a list of wood technology research areas. On the scale from 1 to 5, please indicate what is the emphasis of your institution's current research activities.

5 = Very high priority
4 = Highly important
3 = Important
2 = Slightly important
1 = Not important at all

	1	2	3	4	5
Chemistry of wood and polymers	○	○	○	○	○
Chemical modification of wood	○	○	○	○	○
Theory of wood drying	○	○	○	○	○
Biological deterioration and damages in wood	○	○	○	○	○
New protection concepts for wood and wood products	○	○	○	○	○
Adhesion wood to wood and wood to other materials	○	○	○	○	○
Gluing technologies	○	○	○	○	○
Surface technologies and coating	○	○	○	○	○
Mechanical and physical performance of wood-based structures and joints	○	○	○	○	○
Design and calculation methods and tools for wooden structures	○	○	○	○	○
Fire performance and fire safety of wooden structures	○	○	○	○	○
Reliability analysis of wooden structures	○	○	○	○	○
Wood drying	○	○	○	○	○
Measuring and control technologies, machine vision in wood processing	○	○	○	○	○
Simulation of production systems	○	○	○	○	○
Process control and automation	○	○	○	○	○
Panel products processing	○	○	○	○	○
Modified wood products	○	○	○	○	○
New wood-fibre-based composites	○	○	○	○	○
Functional coatings for wood-based products	○	○	○	○	○
New wood-based product systems	○	○	○	○	○
Low-energy wooden houses	○	○	○	○	○
Interaction of technology and business	○	○	○	○	○
IT tools for simulation, management and optimisation of wood chain	○	○	○	○	○
Logistics and networks in delivery and marketing	○	○	○	○	○
Development of wood construction process	○	○	○	○	○
Market analysis of wood products and wood construction	○	○	○	○	○
Technology strategies, technology forecasting	○	○	○	○	○
Environmental impacts of use of wood and wood products	○	○	○	○	○
Emissions, indoor air	○	○	○	○	○
Maintenance and life-cycle cost of wood construction	○	○	○	○	○
Customer satisfaction with wood products	○	○	○	○	○
Recycling of wood	○	○	○	○	○

Product approval and certification	○	○	○	○	○
External quality control, inspection	○	○	○	○	○
Testing	○	○	○	○	○
Development of testing methods	○	○	○	○	○

If your research institution has some other high priority activities than the above mentioned, please indicate them:

COLLABORATION AND NETWORKING

6. On the scale from 1 to 5, how significant are the following forms of co-operation between your institution and *wood product companies*?.

5 = Very significant
4 = Fairly significant
3 = Significant
2 = Slightly significant
1 = Not significant at all

	1	2	3	4	5
Informal contacts	○	○	○	○	○
Research for companies	○	○	○	○	○
Carrying out testing	○	○	○	○	○
Provision of equipment	○	○	○	○	○
Training	○	○	○	○	○
Consulting	○	○	○	○	○
Exchange of personnel	○	○	○	○	○

7. On the scale from 1 to 5, how significant are the following forms of co-operation between your institution and *other research inctitutions*?

5 = Very significant
4 = Fairly significant
3 = Significant
2 = Slightly significant
1 = Not significant at all

	1	2	3	4	5
Informal contacts	○	○	○	○	○
Joint research projects	○	○	○	○	○
Joint usage of equipment	○	○	○	○	○
Exchange of personnel	○	○	○	○	○

8. Please identify the **three (3)** most significant partner research organisations your institution works together with in Europe.

Name of organisation:
Department:
Contact person:
Areas of expertise:

Name of organisation:
Department:
Contact person:
Areas of expertise:

Name of organisation:

Department:

Contact person:

Areas of expertise:

9. a) How would you want to further develop co-operation with *other research institutes* in the future?

b) How would you want to further develop co-operation with *wood product companies* in the future?

10. Are there any other comments you would like to send to Wood Focus Ltd.?

Submit

Contact: Annika.Mauno@woodfocus.fi

Paavilainen, Leena, Co-ordinator, Wood Focus Ltd.

Kosonen, Esa, Research and Development Manager, Finnforest Ltd.

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Virtanen, Jussi, Researcher, Helsinki University of Technology, Laboratory of Wood Technology.

The tables in the following appendices present the calculated averages, modes and medians of the answers for the question regarding high priority research areas. The formulas and significance of the statistical figures are briefly presented in the following.

Average is the arithmetic mean of the arguments. Average is calculated with *Equation 1*:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \qquad (1)$$

Mode is the most frequently occurring value in a range of data.

Median is the number in the middle of a set of numbers; that is, half the numbers have values that are greater than the median, and half have values that are less. If the number of arguments is odd, median is calculated with *Equation 2:*

$$Md = x_{(n+1)/2} \qquad (2)$$

where x is the greatest value in an array, in which the values are arranged in order from the smallest to the largest value.

If the number of arguments is even, median is calculated with *Equation 3*:

$$Md = \frac{\left(x_{(n/2)} + x_{(n/2)+1}\right)}{2} \qquad (3)$$

Standard deviation is a measure of how widely values are dispersed from the mean. Standard deviation is calculated with *Equation 4:*

$$s_n = \frac{1}{n}\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})} \qquad (4)$$

In marketing research type of questions, the standard deviation reflects how unanimous the respondents were about the issue.

All the definitions are from a free mathematical service provided by Wolfram Research. For further information, see the homepage at

http://mathworld.wolfram.com/

GROUP: ALL RESPONDENTS. N=29	Average	Mode	Median
1. WOOD SCIENCE AND MATERIAL ENGINEERING			
Chemistry of wood and polymers	2,33	1,0	2,0
Chemical modification of wood	2,44	1,0	2,0
Theory of wood drying	2,19	1,0	1,0
2. DURABILITY OF WOOD AND WOOD PRODUCTS			
Biological deterioration and damages in wood	2,85	4,0	3,0
New protection concepts for wood and wood products	3,04	5,0	3,0
3. GLUING AND COATING OF WOOD AND WOOD PRODUCTS			
Adhesion wood to wood and wood to other materials	3,15	5,0	4,0
Gluing technologies	2,63	1,0	2,0
Surface technologies and coating	2,93	5,0	3,0
4. STRUCTURAL SYSTEMS AND JOINTS			
Mechanical and physical performance of wood-based structures and joints	3,78	5,0	5,0
Design and calculation methods and tools for wooden structures	3,44	5,0	4,0
Fire performance and fire safety of wooden structures	2,52	1,0	2,0
Reliability analysis of wooden structures	3,07	5,0	3,0
5. PROCESS TECHNOLOGY AND USE OF NEW TECHNOLOGIES			
Wood drying	2,44	1,0	2,0
Measuring and control technologies, machine vision in wood processing	2,78	1,0	3,0
Simulation of production systems	2,48	1,0	1,0
Process control and automation	2,37	1,0	1,0
Panel products processing	2,19	1,0	2,0
6. DEVELOPMENT OF NEW PRODUCTS AND SYSTEMS			
Modified wood products	3,52	5,0	4,0
New wood-fiber-based composites	3,26	5,0	3,0
Functional coatings for wood-based products	2,59	1,0	2,0
New wood-based product systems	2,93	3,0	3,0
Low-energy wooden houses	2,44	1,0	2,0
7. MODELLING AND OPTIMISATION OF WOOD CHAIN			
Interaction of technology and business	2,74	3,0	3,0
IT tools for simulation, management and optimization of wood chain	2,89	5,0	3,0
Logistics and networks in delivery and marketing	2,59	1,0	2,0
Development of wood construction process	2,70	3,0	3,0
Market analysis of wood products and wood construction	2,59	4,0	3,0
Technology strategies, technology forecasting	2,89	3,0	3,0
8. LIVING WITH WOOD AND ECOLOGY OF WOOD PRODUCTS			
Environmental impacts of use of wood and wood products	3,07	3,0	3,0
Emissions, indoor air	2,30	1,0	2,0
Maintenance and life-cycle cost of wood construction	2,44	3,0	3,0
Customer satisfaction with wood products	3,00	5,0	3,0
Recycling of wood	2,22	1,0	2,0
9. APPROVAL, CERTIFICATION AND TESTING			
Product approval and certification	3,15	5,0	4,0
External quality control, inspection	2,78	1,0	3,0
Testing	3,96	5,0	5,0
Development of testing methods	3,44	5,0	4,0

GROUP: ACADEMIC LABORATORIES OF WOOD RESEARCH , N=8	Average	Mode	Median
1. WOOD SCIENCE AND MATERIAL ENGINEERING			
Chemistry of wood and polymers	3,00	2	3
Chemical modification of wood	3,14	4	4
Theory of wood drying	2,43	1	1
2. DURABILITY OF WOOD AND WOOD PRODUCTS			
Biological deterioration and damages in wood	3,29	4	4
New protection concepts for wood and wood products	2,71	5	2
3. GLUING AND COATING OF WOOD AND WOOD PRODUCTS			
Adhesion wood to wood and wood to other materials	2,29	1	2
Gluing technologies	2,00	1	1
Surface technologies and coating	2,57	2	2
4. STRUCTURAL SYSTEMS AND JOINTS			
Mechanical and physical performance of wood-based structures and joints	2,43	2	2
Design and calculation methods and tools for wooden structures	1,86	1	1
Fire performance and fire safety of wooden structures	1,86	1	2
Reliability analysis of wooden structures	2,43	1	2
5. PROCESS TECHNOLOGY AND USE OF NEW TECHNOLOGIES			
Wood drying	2,57	1	2
Measuring and control technologies, machine vision in wood processing	2,43	1	2
Simulation of production systems	2,71	1	1
Process control and automation	2,57	1	1
Panel products processing	2,71	3	3
6. DEVELOPMENT OF NEW PRODUCTS AND SYSTEMS			
Modified wood products	3,14	1	4
New wood-fiber-based composites	3,14	5	3
Functional coatings for wood-based products	2,00	2	2
New wood-based product systems	2,29	1	2
Low-energy wooden houses	1,29	1	1
7. MODELLING AND OPTIMISATION OF WOOD CHAIN			
Interaction of technology and business	2,43	1	2
IT tools for simulation, management and optimization of wood chain	3,14	5	3
Logistics and networks in delivery and marketing	2,86	1	2
Development of wood construction process	1,86	1	2
Market analysis of wood products and wood construction	3,29	4	4
Technology strategies, technology forecasting	2,57	1	3
8. LIVING WITH WOOD AND ECOLOGY OF WOOD PRODUCTS			
Environmental impacts of use of wood and wood products	3,14	3	3
Emissions, indoor air	2,14	3	3
Maintenance and life-cycle cost of wood construction	2,14	3	3
Customer satisfaction with wood products	3,29	5	4
Recycling of wood	1,71	1	1
9. APPROVAL, CERTIFICATION AND TESTING			
Product approval and certification	2,86	1	3
External quality control, inspection	2,00	1	1
Testing	2,86	1	3
Development of testing methods	2,29	1	2

GROUP: ACADEMIC LABORATORIES OF WOOD CONCSTRUCTION RESEARCH , N=8	Average	Mode	Median
1. WOOD SCIENCE AND MATERIAL ENGINEERING			
Chemistry of wood and polymers	0,71	1,0	1,0
Chemical modification of wood	0,86	1,0	1,0
Theory of wood drying	1,00	1,0	1,0
2. DURABILITY OF WOOD AND WOOD PRODUCTS			
Biological deterioration and damages in wood	1,29	1,0	1,0
New protection concepts for wood and wood products	2,43	1,0	2,0
3. GLUING AND COATING OF WOOD AND WOOD PRODUCTS			
Adhesion wood to wood and wood to other materials	2,71	4,0	2,0
Gluing technologies	1,57	2,0	2,0
Surface technologies and coating	1,57	1,0	1,0
4. STRUCTURAL SYSTEMS AND JOINTS			
Mechanical and physical performance of wood-based structures and joints	4,86	5,0	5,0
Design and calculation methods and tools for wooden structures	4,71	5,0	5,0
Fire performance and fire safety of wooden structures	2,43	2,0	2,0
Reliability analysis of wooden structures	3,57	4,0	4,0
5. PROCESS TECHNOLOGY AND USE OF NEW TECHNOLOGIES			
Wood drying	1,43	1,0	1,0
Measuring and control technologies, machine vision in wood processing	2,14	1,0	1,0
Simulation of production systems	1,43	1,0	1,0
Process control and automation	1,43	1,0	1,0
Panel products processing	1,14	1,0	1,0
6. DEVELOPMENT OF NEW PRODUCTS AND SYSTEMS			
Modified wood products	2,86	1,0	3,0
New wood-fiber-based composites	2,43	1,0	3,0
Functional coatings for wood-based products	1,43	1,0	1,0
New wood-based product systems	2,71	3,0	3,0
Low-energy wooden houses	2,71	3,0	3,0
7. MODELLING AND OPTIMISATION OF WOOD CHAIN			
Interaction of technology and business	2,14	0,0	2,0
IT tools for simulation, management and optimization of wood chain	2,29	5,0	2,0
Logistics and networks in delivery and marketing	1,71	0,0	2,0
Development of wood construction process	3,00	5,0	4,0
Market analysis of wood products and wood construction	1,57	3,0	2,0
Technology strategies, technology forecasting	2,43	2,0	2,0
8. LIVING WITH WOOD AND ECOLOGY OF WOOD PRODUCTS			
Environmental impacts of use of wood and wood products	2,00	2,0	2,0
Emissions, indoor air	0,86	1,0	1,0
Maintenance and life-cycle cost of wood construction	1,57	0,0	2,0
Customer satisfaction with wood products	2,00	2,0	2,0
Recycling of wood	1,00	0,0	1,0
9. APPROVAL, CERTIFICATION AND TESTING			
Product approval and certification	1,86	1,0	1,0
External quality control, inspection	1,57	1,0	1,0
Testing	4,43	5,0	5,0
Development of testing methods	3,43	2,0	3,0

GROUP: OTHER THAN ACADEMICE RESEARCH LABORATORIES, N=13	Average	Mode	Median
1. WOOD SCIENCE AND MATERIAL ENGINEERING			
Chemistry of wood and polymers	2,85	4	3
Chemical modification of wood	2,92	1	3
Theory of wood drying	2,69	1	2
2. DURABILITY OF WOOD AND WOOD PRODUCTS			
Biological deterioration and damages in wood	3,46	5	4
New protection concepts for wood and wood products	3,54	5	4
3. GLUING AND COATING OF WOOD AND WOOD PRODUCTS			
Adhesion wood to wood and wood to other materials	3,85	5	5
Gluing technologies	3,54	5	4
Surface technologies and coating	3,85	5	5
4. STRUCTURAL SYSTEMS AND JOINTS			
Mechanical and physical performance of wood-based structures and joints	3,92	5	5
Design and calculation methods and tools for wooden structures	3,62	4	4
Fire performance and fire safety of wooden structures	2,92	5	3
Reliability analysis of wooden structures	3,15	5	3
5. PROCESS TECHNOLOGY AND USE OF NEW TECHNOLOGIES			
Wood drying	2,92	1	3
Measuring and control technologies, machine vision in wood processing	3,31	4	4
Simulation of production systems	2,92	1	3
Process control and automation	2,77	1	3
Panel products processing	2,46	1	2
6. DEVELOPMENT OF NEW PRODUCTS AND SYSTEMS			
Modified wood products	4,08	5	5
New wood-fiber-based composites	3,77	5	4
Functional coatings for wood-based products	3,54	5	4
New wood-based product systems	3,38	5	4
Low-energy wooden houses	2,92	3	3
7. MODELLING AND OPTIMISATION OF WOOD CHAIN			
Interaction of technology and business	3,02	3	3
IT tools for simulation, management and optimization of wood chain	3,08	3	3
Logistics and networks in delivery and marketing	2,92	3	3
Development of wood construction process	3,00	3	3
Market analysis of wood products and wood construction	2,77	4	3
Technology strategies, technology forecasting	3,31	3	3
8. LIVING WITH WOOD AND ECOLOGY OF WOOD PRODUCTS			
Environmental impacts of use of wood and wood products	3,62	5	3
Emissions, indoor air	3,15	1	3
Maintenance and life-cycle cost of wood construction	3,08	4	3
Customer satisfaction with wood products	3,38	4	4
Recycling of wood	3,15	5	3
9. APPROVAL, CERTIFICATION AND TESTING			
Product approval and certification	4,00	5	5
External quality control, inspection	3,85	5	5
Testing	4,31	5	5
Development of testing methods	4,08	5	5

COLLABORATION BETWEEN RESEARCH INSTITUTES AND INDUSTRY	Average	Standard deviation	Median	Mode
Exchange of personnel	2,1	1,19	2	3
Provision of equipment	2,4	1,47	2	1
Training	3,3	1,35	3	4
Carrying out testing	3,4	1,65	4	5
Consulting	3,8	1,42	4	5
Research for companies	4,1	1,21	5	5
Informal contacts	4,3	1,04	5	5
COLLABORATION AMONG RESEARCH INSTITUTES	Average	Standard deviation	Median	Mode
Exchange of personnel	2,8	1,21	3	3
Joint usage of equipment	2,9	1,24	3	2
Joint research projects	4,4	0,97	5	5
Informal contacts	4,5	0,89	5	5

E1 Paper recyclability
E2 Wood durability
E3 Forestry in the context of rural development
E4 Forest reserves research network (FR-NET)
E5 Timber frame building systems
E6 EUROSILVA : Forest tree physiology research
E7 Multi-phase flows in paper making
E8 Mechanical performance of wood and wood products
E9 Life cycle assessment of forestry and forests products
E10 Wood properties for industrial use
E11 Characterization methods for fibres and paper
E12 Urban forests and trees
E13 Wood adhesion and glued products
E14 Towards zero effluent in paper making
E15 Advances in the drying of wood
E16 Bark and wood boring insects in living trees
E17 Microbiology in paper making
E18 High performance in wood coating
E19 National forest programmes
E20 Wood fibre cell wall structure
E21 Contribution of forests and forestry to mitigate greenhouse effects
E22 Environmental optimisation of wood protection
E23 Biotechnology in the pulp and paper industry
E24 Reliability of timber structures
E25 European network for a long-term forest ecosystem and landscape research programme
E26 Effective solutions to reduce the impact of waste arisings from the papermaking process
E27 PROFOR-Protected Forest Areas
E28 Genosilva : European Forest Genomics Network

E29 Innovative Timber & Composite Elements/Components for Buildings

E30 Economic integration of urban consumers` demand and rural forestry production

E31 Management of Recovered Wood

E32 Characterisation of paper surfaces for improved printing paper grades

E33 Forests for Recreation and Nature Tourism (FORREC)

E34 Bonding of Timber

E35 Fracture mechanics and micromechanics of wood and wood composites with regard to wood machining

E36 Modelling and Simulation and Control in Pulp and Paper Industry

E37 Sustainability Through New Technologies For Enhanced Wood Durability

E38 Woody root processes Stand By

For more detailed information about COST Actions, see the COST homepage at http://cost.cordis.lu/src/home.cfm